REPORT F33657-86-D-0094, 0004

COST OF QUALITY EVALUATION METHODOLOGIES HANDBOOK

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28 JULY 1988

FINAL REPORT

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PREFACE

The Department of Defense and the Air Force have always recognized the need to insist on top quality in the wide variety of material that is purchased in support of the fighting forces. Recently, as part of the emphasis being placed on contractors and their actions relative to providing quality products, visibility into the actual Cost of Quality has become very important.

The concept of Cost of Quality cuts across all functional activities involved in the development and acquisition of weapon systems, related spares, and support equipment. Making Cost of Quality visible is important because it will highlight areas where it is obvious that contractors are trying to inspect or test quality in, rather than build it in. Seeing where contractors are experiencing excessive costs (for example, in inspection, test, reinspection, retest, engineering changes, material, labor, return to vendor, etc.) will enable government and contractor personnel to focus on efforts to find the root causes for these costs and to eliminate those causes.

This handbook was developed for two purposes. First, the handbook explains the concept of Cost of Quality in its basic form and in terms of the major categories of costs involved. Second, the handbook deals with the specific aspects of Cost of Quality involved with individual areas of expertise. Users are shown how to identify and evaluate Cost of Quality elements in their particular discipline. Once captured, Cost of Quality provides a vehicle for good multifunctional communication. Each function can relate to quality issues that cut across several functional lines. In this way, feedback is provided on common problems and effectiveness of solutions. Overall, the handbook will help the user to work with the contractor in the identification, evaluation, and management of Cost of Quality.

A word of caution. The handbook is <u>not</u> a "cookbook" or a "checklist". Rather, it is a guide intended to educate and enable the user to think about Cost of Quality, understand it, and ask the right kinds of questions in order to find the cost. Once found, use of the cost data as a management tool then becomes the main thrust. The handbook is not meant to stand alone. Rather, the visibility into Cost of Quality that can be gained by using the principles provided in the handbook must be related to other contractual requirements, especially MIL-Q-9858A, MIL-STD-1535A, and MIL-STD-1520C, to maximize the total effectiveness of what the government and contractor can and must do to ensure that the highest quality products reach the users in the field.

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INTRODUCTION/OVERVIEW

PURPOSE AND USE OF THE HANDBOOK

The ~~real~~ purpose of the handbook is to function as an aid to the understanding of the concept of cost of quality and its value as a management tool. Individuals who are not a part of a quality assurance organization must recognize that there are activities which go on in their area of interest that are indeed part of the total cost of quality for an organization. Most importantly, the use of the cost of quality information as an aid in identifying problem areas and eliminating problem root causes across all functional areas is the real purpose of capturing the cost of quality in the first place. The handbook will enable all functional personnel to understand cost of quality, find the cost in their area, and judge its use as an effective tool for identifying and eliminating problems.

Proper use of this handbook requires that Chapters one through three be studied in their entirety so that the user can gain a clear understanding of the basic principles underlying the concept of Cost of Quality. Specifically, the user will gain an understanding of the benefits of having visibility into the Cost of Quality and how cost of quality should be used as a management tool. Of particular importance is the recognition that cost of quality is one tool, to be integrated with other tools, such as multidisciplined problem solving under MIL-STD-1520C, for the purpose of reducing and/or eliminating when possible, the generation of nonconforming material.

After absorbing the basic information in Chapters one to three, users can refer to the section in Chapter four which applies to their particular area of expertise. Here the user will find more specific detail on how to determine cost of quality in that partiuclar area of interest. The user <u>will</u> be shown how to evaluate the cost, and how to judge whether or not the contractor is effectively using cost of quality as an integral and effective tool for finding and eliminating causes of defective output. The term output is used here because the "product" supplied may be an engineering drawing, a purchase order, a contract modification, or an electronic circuit card.

This handbook is designed to be used by people involved with proposal evaluation, fact finding, should cost, quality audits, contractor operation reviews, source selection, pre-award surveys, or any review effort in which visibility into what the government is paying for quality would be useful. All disciplines are involved in these types of reviews and all disciplines have a share in the cost of quality. The quality representative involved in a particular review would be the focal point for overall cost of quality evaluation results. <u>But</u> each of the other team members must find the cost of quality in their specific area, evaluate the cost, and make input to the quality representative for consolidation. The handbook is designed to enable each participant team member to accomplish that task in support of the overall cost of quality effort.

As mentioned, the handbook is divided into two major sections. The first section (Chapters one through three) provides the tutorial needed to enable users to fully understand the concept of the cost of quality, what it means, how to identify it, and how it is to be used in analysis. The second section (Chapters four and five) provides specific help by area of expertise to enable users to apply the principles to their particular area of interest. Chapter five also provides insight into methods that can be used to effectively implement and use a cost of quality program.

THE TRUE NATURE OF QUALITY

Before discussing the concept of cost of quality, it is necessary to clearly explain the true nature of quality. The traditional view of quality is focused on the following:

- Quality is the responsibility of the quality department
- Quality relates only to the goodness of the final product, i.e., the products finish, its dimensions, its power output, its operating temperature, etc.
- Manufacturing is the biggest contributor to lack of quality
- Improving Quality will cost more money
- Quality is defined by the manufacturer.

Unfortunately, much of what many people believe about quality is based on these erroneous ideas.

Experts in the quality field today generally recognize that rather than the traditional ideas the real essence of quality is that:

- Everyone in the organization contributes to the ultimate quality of the organization's output. Everyone must be responsible for their contribution to that quality.

- Quality relates to everything that contributes to the final output. The sales person's capturing of the customer's requirements, the designer's translation of those requirements into a design that meets the requirements, the purchasing agent who buys the correct material/parts, the planner who translates the design into production work instructions, the process operator who follows the instructions, the inspector/tester who audits all the above "processes", the packing and crating people who prep the product for final shipment - every one of these people can and does contribute to the ultimate quality of the organization's output, and to the cost of achieving that quality.

- Anyone described above can, and often does, contribute to a lack of quality. Without going through the entire list, it should be obvious that failing to properly perform any one or more of the functions described will degrade the ability of the organization to effectively and efficiently generate quality output. Note the emphasis on effectively and efficiently.

When one function in the organization has to "shore up" the lack of quality in one of its sister functions, their remedial actions drive up costs. Further, the potential for actual degradation of the quality of the final product is greatly increased because errors are basically being tolerated and will ultimately escape the system and effect the product.

- Eliminating errors throughout the entire organization improves quality. Work done to find and correct these errors is eliminated. Costs go down. Non-value added effort can now be channeled into value generating activity. Productivity goes up.

- The customer defines quality. The customer establishes the requirements. Any product or output that meets the customers requirements and expectations will be judged by that customer as being a quality product. The producer cannot decide what is a quality product and say that the customer should recognize it as such. If that product does not meet the customer's requirements and expectations, no matter how fancy the product is or how high and fast it will go, it is not a quality product. Here, it is necessary to talk about internal as well as external customers. Everyone in the organization has customers within that organization, or internal customers. Each of these internal customers defines the quality of the "products" they receive from other functions. For example, manufacturing needs current, producible, and accurate blueprints from design engineering. Purchasing needs timely material requirements from manufacturing, and product specifications from engineering, and quality assurance. Purchasing is both a "customer of" these functions, as well as having them "as customers" of the results of the purchasing effort.

Recognizing that everyone in every function has a role in determining quality, and that finding and eliminating causes of problems will reduce costs and improve output quality is the essence of quality and the basis for using cost of quality as an effective management tool.

The fact that there are indeed "costs of quality" is driven by the requirement that some action is needed to ensure that the various weapon systems and components bought by the Air Force do meet the defined requirement. Some cost of quality must exist. The nature and size of that cost will be driven by a variety of conditions.

- Program phase
- Type of technology/product
- Governmental contractual requirements
- The acquisition strategy
- How the contractor is organized
- How the contractor accounts

The activities that are underway under various functional areas are shown, as an example, in figure ii-1 (note that not all functions are shown). As the reader moves from Chapters one through three and the particular functional section in Chapter four in which he or she is interested, they will find that activities highlighted, and governmental requirements presented, cover the various phases of the acquisition process (see Table 3-1). What the individual evaluator must recognize is that a degree of judgment must be applied when evaluating cost of quality. That judgment must be based first on the functional expertise and experience of the evaluator and, second, on a thorough review of the nature of the effort being evaluated with regard to phase, product, and the above listed conditions.

The goal is not to reduce cost of quality per se. The goal is to use cost of quality to understand where the costs are, by function and by category, and to understand what those costs reveal about both the contractor's approach to quality and the effectiveness of that approach. Proper management of the quality effort to achieve a "prevention" posture will provide the best return to the government on money spent, and will result in an eventual lowering of total cost of quality.

ACQUISITION LIFE CYCLE TECHNICAL ACTIVITIES

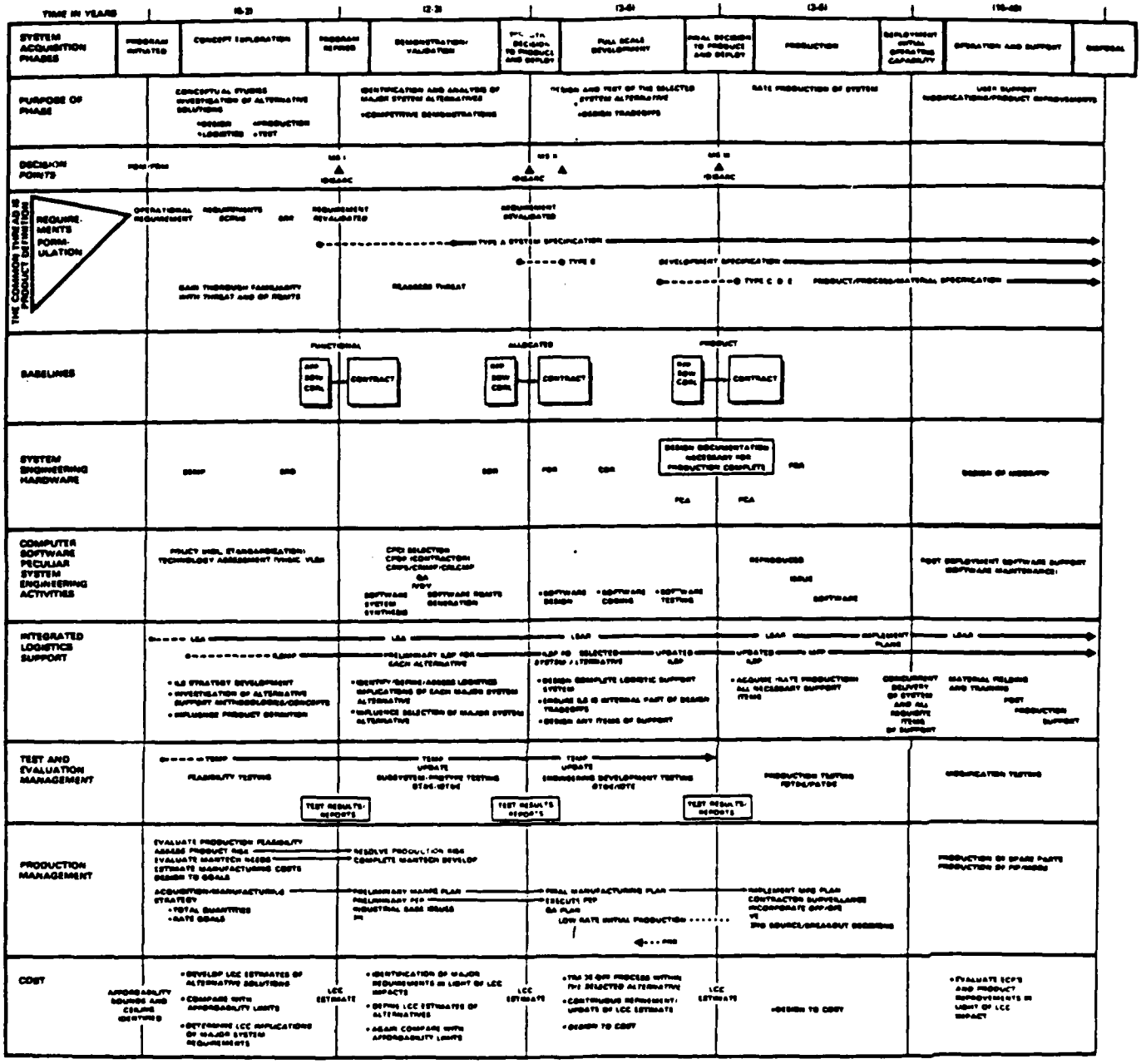

Figure ii-1

EXECUTIVE SUMMARY

The Cost of Quality Evaluation Methodologies Handbook was developed for two purposes. First, the handbook provides a detailed tutorial on the meaning and value of the cost of quality concept. Second, the handbook provides specific guidance, by functional area, on how to find the cost of quality, how to judge its meaning, and how to use it in combination with other performance indicators to judge the effectiveness and efficiency of the contractor's quality program.

Traditionally, quality has been seen as the responsibility of the Quality and Manufacturing departments. Quality has been "inspected in". Most people believed that it costs more money to improve quality. Nonconformances were accepted as inevitable, and were handled through scrap, rework, repair, or use as-is.

The traditional view has been wrong. It is now generally recognized in the quality profession, and more importantly, well beyond, that quality is everyone's responsibility. Every function contributes to the organization's ability to create quality output. For example, customer requirements must be accurately captured and communicated. Engineering drawings must be correct. Purchase orders must be complete and accurate. Work instructions must be clear and performable. Tests must be set up properly and the right data collected and correctly interpreted. Inspections must be focused on the important characteristics and attributes. Shipping and handling must protect the product and get it to the right customer. Failure in any one or more of these functions will adversely affect quality. The costs associated with ensuring the quality of any functional area "output" is the essence of the cost of quality concept. It is present in everybody's functional area.

- The traditional approach to cost of quality has focused on scrap, rework and repair, which represents FAILURE. True cost of quality consists of four cost categories.
  - Appraisal costs - looking for nonconformances
  - Failure costs - disposing of nonconformances
    - Internal - before final delivery
    - External - after final delivery
  - Prevention - avoiding nonconformances

- o These cost categories are present for <u>every</u> function in a company, not just for the quality and manufacturing functions.

The cost of quality is not an end, but a means to an end. It provides visibility for management:

- o into the total cost of the quality effort.
- o into problems reflected by the relationships between each category, relative to each other, and to the total.
- o into lower organizational level contributions to the quality effort.
- o into the effectiveness of corrective actions.

The relationship between each cost of quality category is important, and can tell a great deal about whether a given quality program is "inspection focused" or "prevention focused". Figure iii-1 illustrates the point.

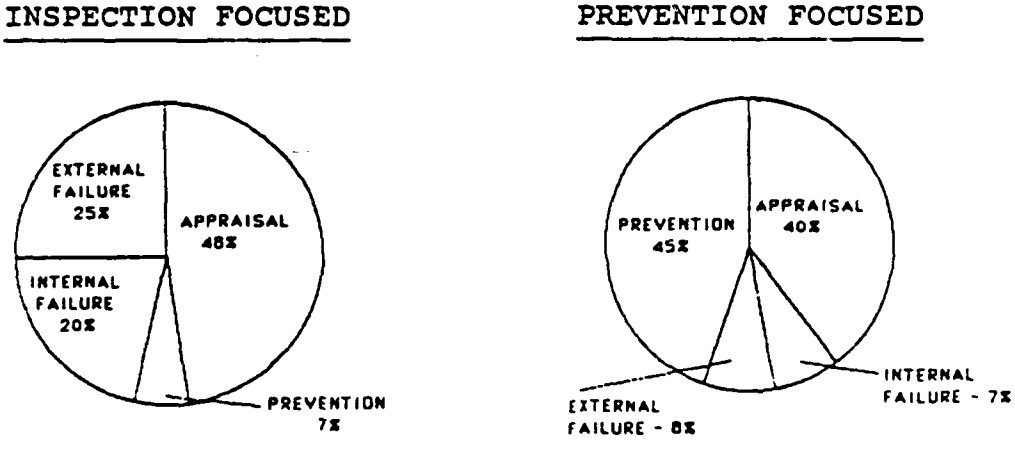

Figure iii-1

Unless management analyzes the true composition of the cost of quality relative to what is being contributed to each category by various organizational levels, and takes action to eliminate problems highlighted by cost of quality figures, having the data serves no worthwhile purpose.

The authority for the government to require defense contractors to collect and use cost of quality data stems from: the direction and instructions contained in the Federal Acquisition Regulation; Department of Defense Directives and Instruction; various military specifications and standards; and more specifically MIL-Q-9858A, paragraph 3.6, "Cost of Quality". Contractors are spec-

ifically required to collect cost on "prevention and correction". Correction is failure cost, as it deals with disposition; and fits the failure cost definitions.

Cost of Quality data will normally be found as both direct and indirect costs. Direct costs can usually be found in existing reports, etc. Indirect costs require more effort to develop an accurate estimate. A methodology has been provided in the handbook that enables an analyst to determine the actual work content of a given function. Based on the average time required to perform each task, and the frequency of the task, an accurate estimate of the total hours can be made. From that estimate, those tasks that meet the cost of quality category definitions can be segregated, and cost of quality estimated for that function. Combining the functional cost of quality data provides a total cost of quality figure.

Now that the cost of quality is available, by functional area and as a total, action can be taken to use the data as a management tool. Areas weak on prevention can be addressed. Improvement progress can be tracked.

People in every functional area must be able to find and use cost of quality information. The handbook provides guidance in this regard for each of the following functions:

Program Management
Engineering
Manufacturing
Finance
Quality Assurance
Subcontractor Management
Logistics
Contracts

Each functional section provides tests of typical functional activities, and break out costs of quality for each activity. Guidance is also provided on which category of cost of quality is involved, what contractual requirement may drive that cost, and what are typical measures of that cost in terms of functional performance (e.g., drawing errors/1,000 drawings; percentage of purchase orders with errors; average errors per work instruction, etc.).

Once cost of quality data is available, its meaning can be judged in combination with other cost performance indicators. For example, under C/SCSC, variance from budget can be looked at for evidence that cost of quality factors are contributing to the variance. Likewise, under MIL-STD-1567A, Work Measurement, variance analysis can now include judgments about what role cost of quality is playing in labor performance.

Cost of quality provides a valuable tool for both government and industry. Cost of quality, when properly accounted for in all functional areas, shows what it really costs to get the product

to the field. If that product is not performing satisfactorily, then judgments can be made about the effectiveness and efficiency of those resources being expended in the quality effort. Action can be taken and results tracked to correct the situation.

BASIC EXPLANATION OF COST OF QUALITY

COST OF QUALITY

What is the cost of quality? The traditional approach to this question has seen cost of quality as the cost of failure, or spoilage, or the effort required to bring material that does not conform to requirements back to a state where the material is once again acceptable for use. The focus has been on scrap, rework, and repair. The data examined has encompassed the cost of the material, and the man hours required for disposition of material by manufacturing. Often the data is expressed as a percentage of direct labor, or in the case of the material, a percentage of total work center output value.

The approach described above is one focused purely on FAILURE. Such an approach falls short of identifying the true cost of quality for the organization, and more importantly, fails to support the need for multidisciplined evaluation of problems to find the true root causes of errors and to eliminate those causes. Failure costs are definitely a part of the cost of quality, but only one part.

The cost of quality is:

> "the cost of all efforts expended to find nonconforming output, react to actual failures, both internally and externally, and to prevent failures from happening in the first place".
>
> "costs expended in the effort to find non-conforming output are called appraisal costs".
>
> "the costs of actual failures themselves and their correction are called internal failure and external failures costs".
>
> "the costs of efforts designed to stop problems or failures from occurring in the first place are called prevention costs".

We will begin by looking at definitions of each of the primary categories of cost of quality.

Appraisal Costs

These are costs that anyone expends in an effort to judge the acceptability of output and to identify any instance of non-conformance. Key terms here are evaluation activity, measure, or audit. The emphasis is on compliance with quality standards and/or performance requirements for any "output" (purchase order, engineering drawing, circuit card, actuator, etc.).

Failure Costs

These are costs that are associated with activity required to evaluate and either correct or replace output that fails to meet established quality standards and/or performance requirements. The emphasis is on the decision regarding what to do and then the resultant action. Key terms are determine, disposition, rework, scrap, repair, reaccomplish, or correct.

There are two types of failure costs:

Internal Failure

These are incurred prior to final delivery of the specific output to the customer (internal or external customer).

External Failure

These are incurred after final delivery of the specific output to the customer (internal or external customer).

Prevention Costs

These are costs incurred through efforts to avoid nonconforming output from occurring in the first place. These include actions that occur prior to or during all phases of business activity. The key idea here is that these actions are aimed at ensuring activities will be done correctly before the activities actually take place. Thus, errors are prevented from happening in the first place.

Understanding the general concept of each category is important. First, knowing what costs fall under each category requires a clear understanding of what each category means. Second, the level of cost in each category can tell you a great deal about what kind of approach an organization has towards quality in general. Third, the relative size of each category, when compared to each other as well as to the total cost of quality, is again an indicator of possible courses of action needed to address quality issues in that organization.

Table 1-1 provides examples of the types of activities that can be found under each of the four main categories. Table 1-1 was taken directly from the American Society for Quality Control publication, "Principles of Quality Costs".

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DETAILED QUALITY COST DESCRIPTION SUMMARY

1.0 PREVENTION COSTS	2.0 APPRAISAL COSTS
1.1 Marketing/Customer/User	2.1 Purchasing Appraisal Costs
1.1.1 Marketing Research	2.1.1 Receiving or Incoming Inspections and Tests
1.1.2 Customer/User Perception Surveys/Clinics	2.1.2 Measurement Equipment
1.1.3 Contract/Document Review	2.1.3 Qualification of Supplier Product
1.2 Product/Service/Design Development	2.1.4 Source Inspection and Control Programs
1.2.1 Design Quality Progress Reviews	2.2 Operations (Manufacturing or Service) Appraisal Costs
1.2.2 Design Support Activities	2.2.1 Planned Operations Inspections, Tests, Audits
1.2.3 Product Design Qualification Test	2.2.1.1 Checking Labor
1.2.4 Service Design Qualification	2.2.1.2 Product or Service Quality Audits
1.2.5 Field Trials	2.2.1.3 Inspection and Test Materials
1.3 Purchasing	2.2.2 Set-Up Inspections and Tests
1.3.1 Supplier Reviews	2.2.3 Special Tests (Manufacturing)
1.3.2 Supplier Rating	2.2.4 Process Control Measurements
1.3.3 Purchase Order Tech Data Reviews	2.2.5 Laboratory Support
1.3.4 Supplier Quality Planning	2.2.6 Measurement Equipment
1.4 Operations (Manufacturing or Service)	2.2.6.1 Depreciation Allowances
1.4.1 Operations Process Validation	2.2.6.2 Measurement Equipment Expenses
1.4.2 Operations Quality Planning	2.2.6.3 Maintenance and Calibration Labor
1.4.2.1 Design and Development of Quality Measurement and Control Equipment	2.2.7 Outside Endorsements and Certifications
1.4.3 Operations Support Quality Planning	2.3 External Appraisal Costs
1.4.4 Operator Quality Education	2.3.1 Field Performance Evaluation
1.4.5 Operator SPC/Process Control	2.3.2 Special Product Evaluations
1.5 Quality Administration	2.3.3 Evaluation of Field Stock and Spare Parts
1.5.1 Administrative Salaries	2.4 Review of Test and Inspection Data
1.5.2 Administrative Expenses	2.5 Miscellaneous Quality Evaluations
1.5.3 Quality Program Planning	
1.5.4 Quality Performance Reporting	
1.5.5 Quality Education	
1.5.6 Quality Improvement	
1.5.7 Quality Audits	
1.6 Other Prevention Costs	

3.0 INTERNAL FAILURE COSTS	4.0 EXTERNAL FAILURE COSTS
3.1 Product/Service Design Failure Costs (Internal)	4.1 Complaint Investigations/Customer or User Service
3.1.1 Design Corrective Action	4.2 Returned Goods
3.1.2 Rework Due to Design Changes	4.3 Retrofit Costs
3.1.3 Scrap Due to Design Changes	4.3.1 Recall Costs
3.1.4 Production Liaison Costs	4.4 Warranty Claims
3.2 Purchasing Failure Costs	4.5 Liability Costs
3.2.1 Purchased Material Reject Disposition Costs	4.6 Penalties
3.2.2 Purchased Material Replacement Costs	4.7 Customer/User Goodwill
3.2.3 Supplier Corrective Action	4.8 Lost Sales
3.2.4 Rework of Supplier Rejects	4.9 Other External Failure Costs
3.2.5 Uncontrolled Material Losses	
3.3 Operations (Product or Service) Failure Costs	
3.3.1 Material Review and Corrective Action Costs	
3.3.1.1 Disposition Costs	
3.3.1.2 Troubleshooting or Failure Analysis Costs (Operations)	
3.3.1.3 Investigation Support Costs	
3.3.1.4 Operations Corrective Action	
3.3.2 Operations Rework and Repair Costs	
3.3.2.1 Rework	
3.3.2.2 Repair	
3.3.3 Reinspection/Retest Costs	
3.3.4 Extra Operations	
3.3.5 Scrap Costs (Operations)	
3.3.6 Downgraded End Product or Service	
3.3.7 Internal Failure Labor Losses	
3.4 Other Internal Failure Costs	

Table 1-1

Reprinted by permission, American Society for Quality Control, "Principles of Quality Costs", 1986

Appendix A contains other lists taken from various studies and publications. As mentioned earlier, understanding what costs fall under each category requires a clear understanding of what each category means. Careful study of the definitions given above and the information in table 1-1 and Appendix A should give the reader a good grasp of the basics. Note also that more detail is provided in the individual functional sections found in Chapter four of the handbook.

One word of caution: It is easy to become overly concerned about very precise placement of costs in the appropriate category. While a certain degree of accuracy is certainly important to avoiding the erroneous inflation or reduction of a given category, experience has shown that the number of controversial costs is usually small and that the danger of skewing the data is small. The best rule to follow is to go back to the basic definitions of the categories.

Let's look at two examples. One might conclude that inspecting a problem area with the purpose of preventing defects from getting out is an example of prevention costs. Go back to the definitions. Prevention costs are incurred through efforts to avoid non-conforming output from occurring in the first place. The inspection here is clearly finding defects after they have occurred. These inspection costs are appraisal, or costs incurred in an effort to judge the acceptability of output and to identify any instance of non-conformance. Remember the key terms: evaluate, measure, or audit.

Another example could be an organization which has found that a group of operators has been turning out excessive amounts of nonconforming output. The problem turned out to be a lack of clear understanding of requirements, so training was initiated. Isn't the cost of training part of the failure costs, since the training is the corrective step resulting from the defects? Again, refer back to the definitions. Failure costs are those associated with activity required to evaluate and correct or replace output that fails to meet established quality standards and/or performance requirements. Remember the key terms: determine, disposition, rework, scrap, repair, reaccomplish, or correct. Once the defective output has been dispositioned, attention is turned to determining why the defects occurred in the first place and how to prevent them from recurring. The training is designed to do that and therefore it is a prevention cost, in line with the definition for the prevention category.

BENEFITS OF COST OF QUALITY

Now that the cost of quality categories are known and the various costs that are associated with each category are recognized, the value of having these costs can be discussed. A very important point must be made. Remember: the cost of quality is not an end in itself, but a means to an end. Cost of quality represents one of many tools available for use in improving the overall quality of the products that the Department of Defense buys for use by defense personnel. As a beneficial tool, cost of quality:

1. provides visibility into the total cost of ensuring requirements are being met.

2. points to problems in the quality program that are reflected in cost of quality category imbalances, or excessive costs in the non-value added areas of quality activity.

3. acts as a diagnostic tool at lower organizational levels in identifying problem areas.

4. allows judgements about the real thrust of a given quality effort from the perspective of "inspecting quality in" versus "designing and building quality in".

5. allows management to judge the effectiveness of corrective actions taken to eliminate root causes and improve quality.

Once cost of quality has provided the above benefits, other quality management tools can then be applied to work problems and develop solutions. A contractor cannot be expected to successfully eliminate causes for defective material unless he has good visibility into where his problems are. Assuming he is doing what is required under other contractural requirements, such as MIL-Q-9858A and MIL-STD-1520, his overall effort will now be significantly enhanced due to the benefits of having cost of quality data available. Let's examine the benefits and see how each is realized.

Benefit 1: Provides visibility into the total cost of ensuring requirements are being met. Experts in the field of quality today agree that the total cost of quality, expressed as a percentage of sales, averages between 15% and 30% for American Companies. If the reader is familiar at all with the traditional measures of scrap, rework, and repair, these numbers totaled as a percent of sales, are typically between 5 and 10%. Why the difference? Because scrap, rework, and repair only represent FAILURE COSTS, and more specifically, INTERNAL FAILURE COSTS. Appraisal and prevention costs, and external failure costs must be added in for a true picture of the cost of quality. Seeing these other cost categories is vital because:

- appraisal costs show what it costs to find the items that require scrap, rework, repair, or use as-is actions.

- prevention costs show what level of effort is being expended to avoid defective output, that is scrap, rework, or repair actions in the first place.

- external failure costs show what costs are incurred after the output is in the hands of the customer and it fails to meet customer requirements.

It should be obvious that seeing all the cost categories, in all functional areas, is the only way to know the true total cost of the quality effort.

Benefits 2: Points to problems in the quality program that are reflected in cost of quality category imbalances, or excessive costs in the non-value added areas of quality. Now that the total cost is visible, and particularly in view of why each category is important as described above, attention can be turned to the relative importance of each category, both to the total and to each other. Look at figure 1-1.

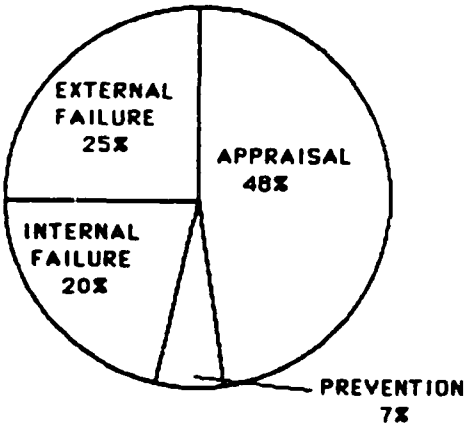


figure 1-1

Note that fully half the cost is incurred just finding defective output (appraisal). Just short of half is incurred in dispositioning the defects after discovery (failure). Only 7% is incurred in efforts to prevent defects from occurring in the first place. What does all this mean?

- If this is a MIL-Q-9858A contractor, compliance with paragraph 3.6, which calls for "prevention and correction of defects" is clearly heavy on the correction side.

- Failure costs are high as a percentage of the total because very little is being done to prevent defects from occurring.

- If this is a MIL-STD-1520C contractor, multidiscipline action to determine and eliminate root causes for defects is not being effectively implemented.

For the Air Force analyst, a logical next step with this contractor would be to look at data on repeat nonconformances and overall defect level trends. Chances are excellent that the data would show:

- high incidence of repeat nonconformances.

- fairly stable, or flat trends, showing no real improvement over time.

The importance of cost of quality data should now be clearly apparent, particularly as an aid to point one toward other indications of quality activity in order to make judgements about whether the government is getting what is is paying for from the contractor's quality system. The contractor is being paid to find and correct defects and to eliminate the causes, so as to prevent the defects from recurring in the future. Further, prevention should be active up front, to prevent many potential defects from ever occurring in the first place. A contractor operating with relative costs of quality categories as shown in figure 1-1 will, in all likelihood, have a total cost of quality in the 15 to 35% of sales range.

Now look at Figure 1-2.

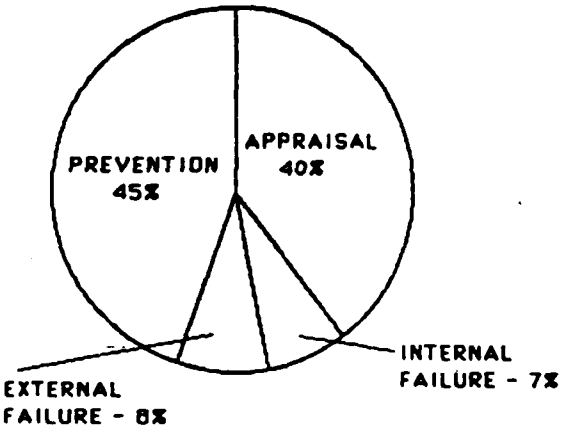


Figure 1-2

Note that almost fully half of the total cost is incurred in preventing defects from occurring in the first place or from reoccurring. Also note that as a percentage of the total, appraisal costs is 40%, not far from the percentage in figure 1-1. Does this mean the contractor in figure 1-2 is still inspecting in "quality"? The answer is no, for the following reasons:

- with the heavy emphasis on prevention (assuming it is an effective effort) defects are being avoided in the first place, and those that do occur are not repeating in the future.

- the appraisal effort is necessary to ensure that the prevention effort is indeed working as intended.

- the low failure cost percentages would tend to indicate the prevention program is effective.

- with this type of program, looking at data on repeat defects and defect trends over time will likely show very low repeats and excellent downward trends.

Although appraisal is at 40% of the total, a contractor with relative costs of quality as shown in figure 1-2 will usually have a total cost of quality in the 5 to 10% of sales range. In this case, the actual appraisal effort, and its associated cost, is much smaller compared to the effort in figure 1-1, because the total cost of quality is lower.

As a further example of the above discussion dealing with figures 1-1 and 1-2, real data from The Tennant Company, a company that has successfully implemented a quality program oriented toward preventing defects in the first place, and preventing reoccurrence of defects that do occur, is presented in figure 1-3.

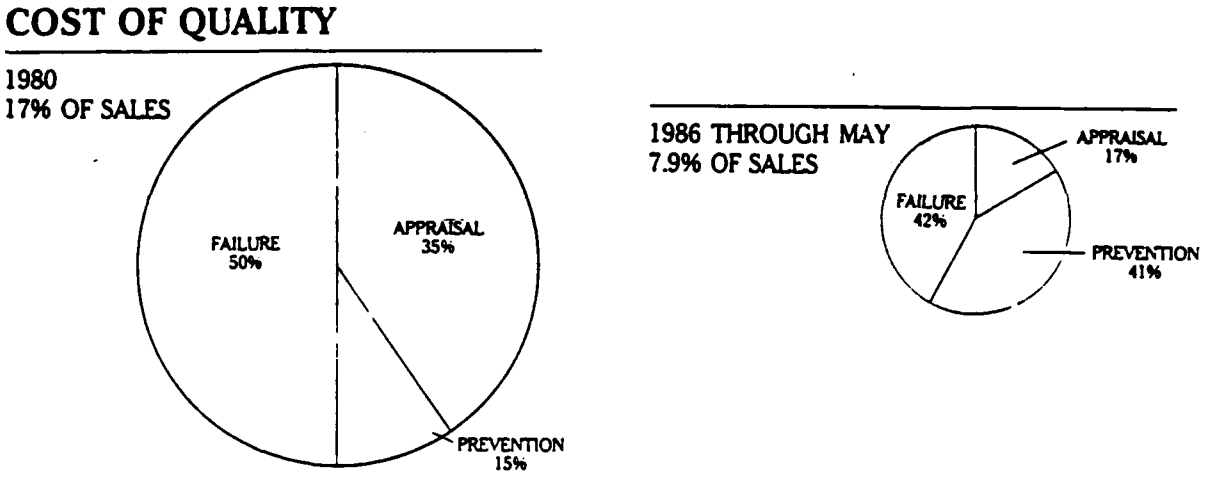


figure 1-3

Reprinted by permission, Tennant Company, "Quest for Quality", 1987

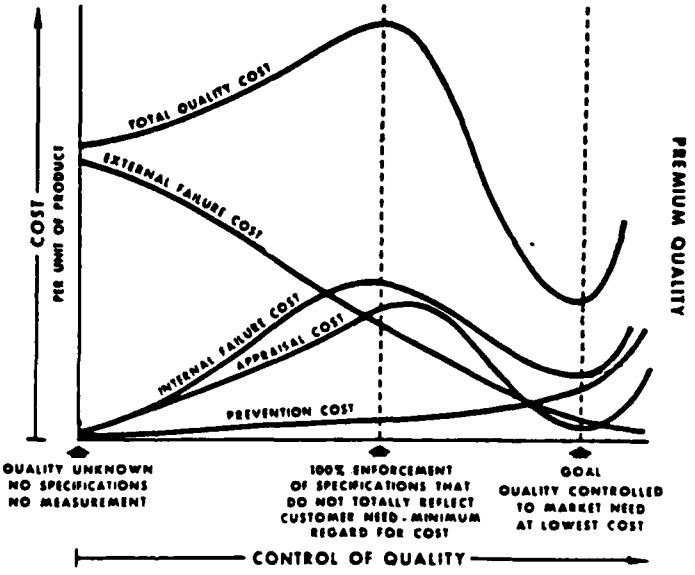
Notice that as effort in prevention grew as a percentage of the total cost of quality, the total cost fell dramatically. Note also that appraisal as a percentage of the total fell. But this company expects appraisal to stabilize at about the original percentage of the total. This is because the quality organization in this company is now performing essentially an audit function to ensure everyone else's quality efforts are effective. The emphasis on everybody is important, and ties very well to the concepts of MIL-STD-1520C. A multidisciplined approach to analyzing the root causes of quality problems recognizes that many functions can and often do contribute to generation of defective output. Unless every potential contributor takes an objective look at where they could have done something to cause the defect, real identification and elimination of root causes cannot take place.

Why does the emphasis on prevention result in lower overall cost of quality and better quality in the end product?

- preventing nonconformances occurs through good analysis of all "processes" and refinement of those processes so they produce little, if any, defective output.
- once confidence is gained in "process" capability, less appraisal effort is needed to continue to verify process integrity.
- less nonconforming output is generated that requires disposition actions.
- less failures occur in the field due to nonconforming products.

As an illustration of what happens look at figure 1-4.

figure 1-4



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Notice that the 100% enforcement point reflects high appraisal and failure and overall total cost of quality, with low prevention. The goal is to optimize total cost of quality through that increase in prevention needed to eliminate defective output, such that failure and appraisal costs are minimized. Notice that external failure is low at the goal point, thus providing the customer the best output possible.

Benefit 3: Acts as a diagnostic tool at lower organizational levels in identifying problems areas. Looking back at table 1-1 we are reminded of the large variety of individual cost elements that go in to each of the cost of quality categories. For example, under prevention costs in table 1-1 we find:

- Operations (Manufacturing or Service)
  - Operations Process Validation
  - Operation Quality Planning
  - Design and Development of Quality Measurement and Control Equipment
  - Operation Support Quality Planning
  - Operator Quality Education
  - Operator SPC/Process Control

Consider a final assembly area for a complex mechanical product, such as a jet engine. The cost of quality for the area is again made up of the categories of prevention, appraisal, and internal and external failure. The costs at this level contribute to the overall totals for the company. Look now at figure 1-5.

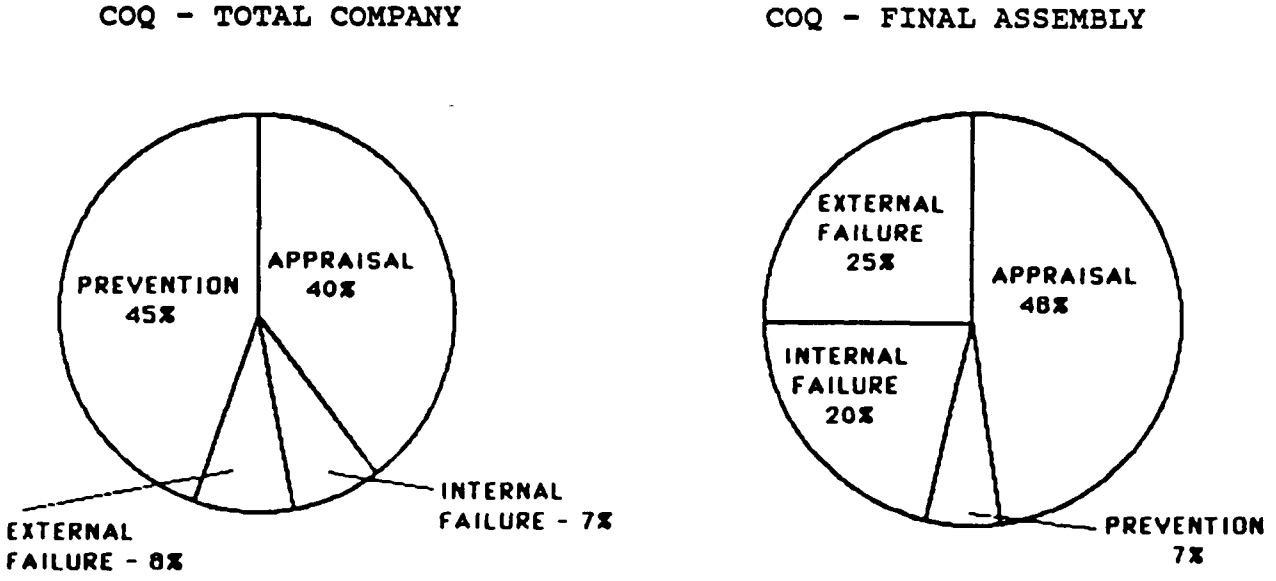


Figure 1-5

It is entirely possible for a lower level unit within the company to have cost of quality relationships that are significantly different from those for the total company, as shown in figure 1-5. The manager in final assembly should be concerned. It is obvious that a hard look is needed at what is being done in the area of prevention. Action should include looking at the cost elements listed above from table 1-1 for Operations, since final assembly is essentially the

operation of putting the product together. The types of failures being found by the appraisal effort should also be examined to determine those that could be prevented by proper emphasis on the individual prevention cost elements, and more specifically, the prevention activity that generates those cost elements. Valid questions to ask are:

- What are the failures we are experiencing?
- Which ones are contributing most to failure costs?
- Why are they occurring?
- What prevention effort is underway to address these high contributors?
- Is current prevention failing?
- What are all the possible causes for these high contributors?
- What prevention action can be put in place to eliminate these failures now and in the future?

Once these actions are taken the manager can then move to benefit #5, having visibility into cost of quality, discussed below.

A word here about use of cost of quality data by top management is appropriate. Refer again to figure 1-5. If top management looks only at the total cost of quality and the relationship between the categories they are not going far enough. In the above example, looking at figure 1-5, Cost of Quality - Total Company, at the make up of the 45% prevention relative to each major function's contribution may reveal the following (figure 1-6).

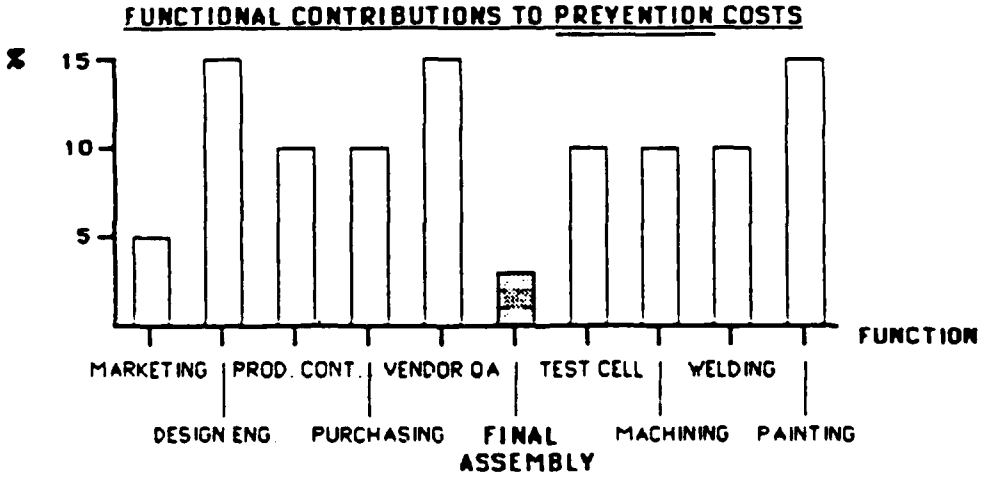


FIGURE 1-6

Although prevention is 45% of the total cost of quality, final assembly is low relative to the percentage of contribution of the other functions. The next question to ask is, "What are the relative contributions to failure costs (figure 1-7)?"

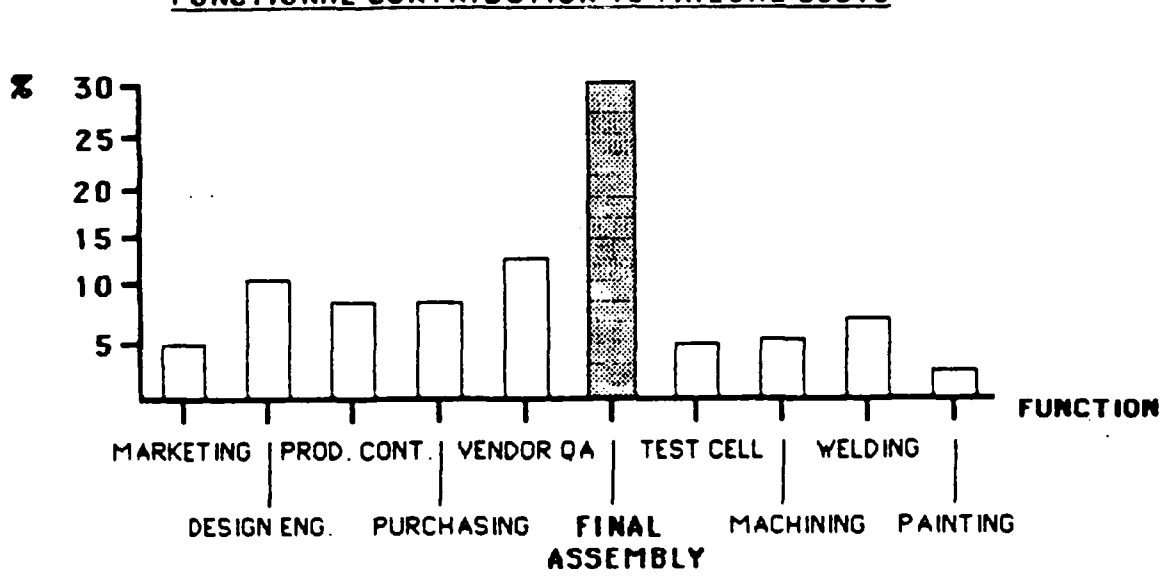


FIGURE 1-7

It is obvious that 30% of the total company failure costs come out of final assembly. In view of the lower effort in prevention and the high level of failure contribution, top level management should be looking to final assembly management to analyze the situation, take action, and report back.

There are a variety of circumstances that can and do dictate the relative relationships among functional elements and their contributions to cost of quality. The example is intended to make the point that management at all levels must use cost of quality data as a tool to help identify and solve problems.

Benefit 4: Allows judgements about the real thrust of a given effort to improve or manage quality from the perspective of "inspecting quality in" versus "designing and building quality in". As discussed under benefit 1, the relative size of prevention and failure costs to each other and to total cost of quality can be used to determine the approach to quality being taken by a given company. When failure is very high and prevention low, then appraisal effort is mostly to find defective output, which is then dispositioned. On the other hand, when prevention is high and failure is low, appraisal is mostly to verify that prevention is indeed working. Appraisal of actual output can be reduced and the focus changed to audit of processes to ensure process integrity is maintained so that nonconforming output does not occur. (All processes, not only manufacturing processes.)

Benefit 5: Allows management to judge the effectiveness of corrective actions taken to eliminate root causes and improve quality. As discussed under benefit 3, once a manager has recognized that a problem exists by evaluating his cost of quality information, he can then monitor the effectiveness of any action taken to correct the situation by watching how his cost of quality reacts. The cost elements that go into his cost of quality should also be checked to be sure specific actions are taken (costs here increase) and that failures are being eliminated as a result of these specific actions (costs here decrease).

BASES USED IN COST OF QUALITY

Another important area to consider in a discussion of the concept of the cost of quality is the subject of the bases used for calculating cost of quality and for making judgements about what the costs mean. Any base chosen will vary in absolute terms over time as the level of business activity changes. Experience has shown that no matter what the base, expressing cost of quality as a percentage of that base has proven to be the most useful approach. Keep in mind that cost of quality is measured for two primary reasons. First, cost of quality helps to identify areas which need attention for making improvements. Second, once action to improve is underway, cost of quality provides a means of measuring the actual improvement achieved.

In deciding the bases to be used, a close working relationship is needed between the accounting, manufacturing, and quality departments. An easy way to start is for an organization to look at what bases are currently measured. One advantage of using this approach is that it requires no changes in the current accounting system. A second advantage is that using existing bases keeps the information on a footing that is already well established and understood within the company. Management often already reacts to these bases, so expressing cost of quality in these terms can make an impact on acceptance of the cost of quality numbers and the use of those numbers as management tool.

Bases that are frequently used include:

- total production costs
- net sales
- total purchased material costs
- total work center output
- direct labor hours
- productive direct labor
- shop - cost input
- contributed value

- equivalent units of productive output

When a company selects the bases to be used, several important factors must be considered:

- Are the bases sensitive to increases and decreases in production schedules?
- If methods improvements through equipment modernization are achieved, will the bases be affected by lower direct costs?
- Are they affected by normal fluctuations in sales?
- Are they sensitive to fluctuations in the price of materials?

The matrix provided in Table 1-2 shows the applicability of these factors to each of the bases previously listed:

BASE FACTORS

	Sensitive to Prod. Sch.	Moderni-zation/lower Direct Labor	Seasonal Fluctuation	Materials Price
Total Production Costs	X			
Net Sales			X	
Total Purchased Material Costs				X
Total Work Center Output	X	X		X
Direct Labor Hours	X	X		
Productive Direct Labor	X	X		
Shop Cost Input	X			
Contributed Value		X		
Equivalent Units of Productive Output	X	X		

TABLE 1-2

Certain bases may be more appropriate for use in one area than in another. It is perfectly acceptable to use a different base among lower level cost centers. For example, production would be interested in, perhaps, internal failure costs as a percent of total production costs. Purchasing, on the other hand, may want to look at appraisal costs as a percentage of total purchased material costs. Engineering may want to consider prevention costs as a percent of design engineering labor costs. The base selected should be one that is a true reflection of what is being expended against the quality effort for that area.

As part of the development of this handbook, interviews were conducted with a variety of companies doing business with the government. Among the questions asked was "How are you expressing the cost of quality?" The overall results of these interviews are provided in Chapter 3, and Appendix D, but in terms of bases being used we found generally:

- cost expressed as dollars
- cost expressed as % of man hours
- cost expressed as % defective
- cost expressed as material cost in dollars
- cost expressed as a % of sales

JUDGING THE MEANING OF COST OF QUALITY INFORMATION

A major problem for a government analyst in looking at cost of quality numbers is how to judge their meaning for an individual program. For example, is the company collecting cost of quality by department, by program, and by business unit, or only as a total? As shown in our example earlier, dealing with the total company versus the cost of quality for final assembly, it is very important for management to understand what goes into a company total, and for lower level management to understand what their unit contribution represents. The breakdown of contributions to the total cost numbers should be driven by a logical application of the structure of the organization. For example, see Figure 1-8.

EXAMPLE COMPANY STRUCTURE

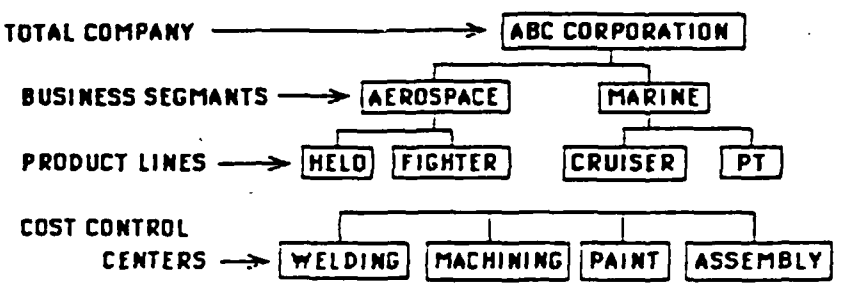
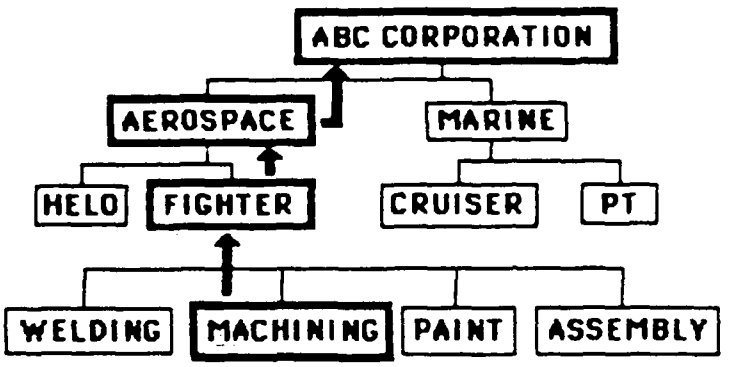


FIGURE 1-8

Understanding the contribution of each of the levels in Figure 1-8 to the total company cost of quality categories is important. Adverse trends, or unusually high cost at a lower level, may be masked when combined with all other cost center input. With this in mind, looking again at Figure 1-8, one could consider looking at, for example, internal failure for "machining" as a contributor to "Manufacturing" as a contributor to "Fighter", as a contributor to "aerospace", as a contributor to "total company" cost of quality (figure 1-9).

PULLING UP COST OF QUALITY CONTRIBUTION THROUGH THE STRUCTURE OF THE COMPANY



FIGUR E 1-9

EVALUATING THE COST OF QUALITY

How do you know if the cost of quality is too high or too low, or just about right? Is there an "acceptable range" for cost of quality? Is continual improvement the real goal?

Recognize that at the producer there must be some cost of quality. Otherwise there would be no control over output and no measurement of whether that output met requirements. It would be up to the user to prove the item's quality through actual use. If it performed as required and met all requirements, it would be judged a quality product. If it failed, it would not be judged a quality product. However, allowing for the user to find out whether the product is usable or not is not the way to determine the quality. The manufacturer must take some action to determine the product's acceptability before delivery. (See Figure 1-10).

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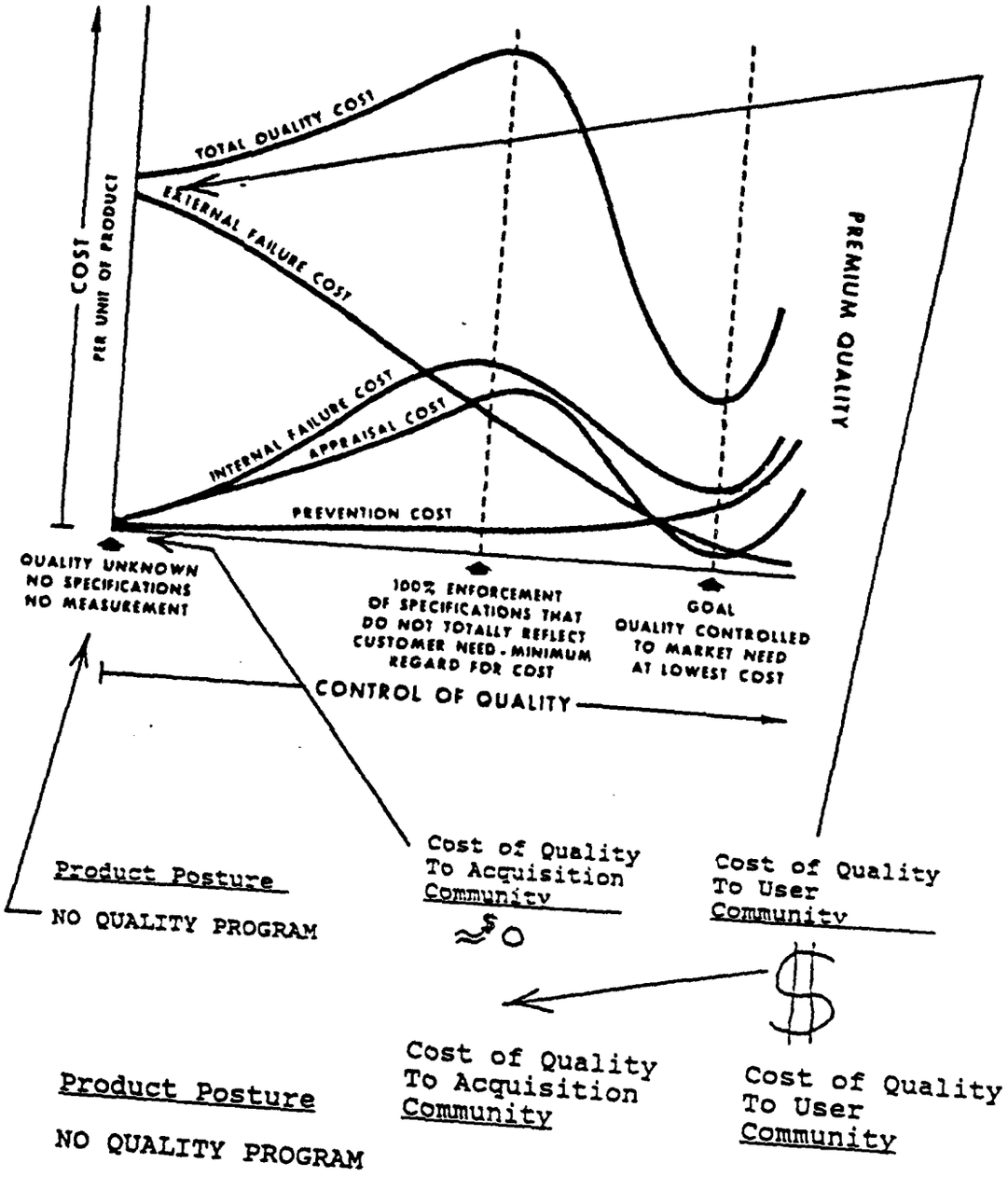
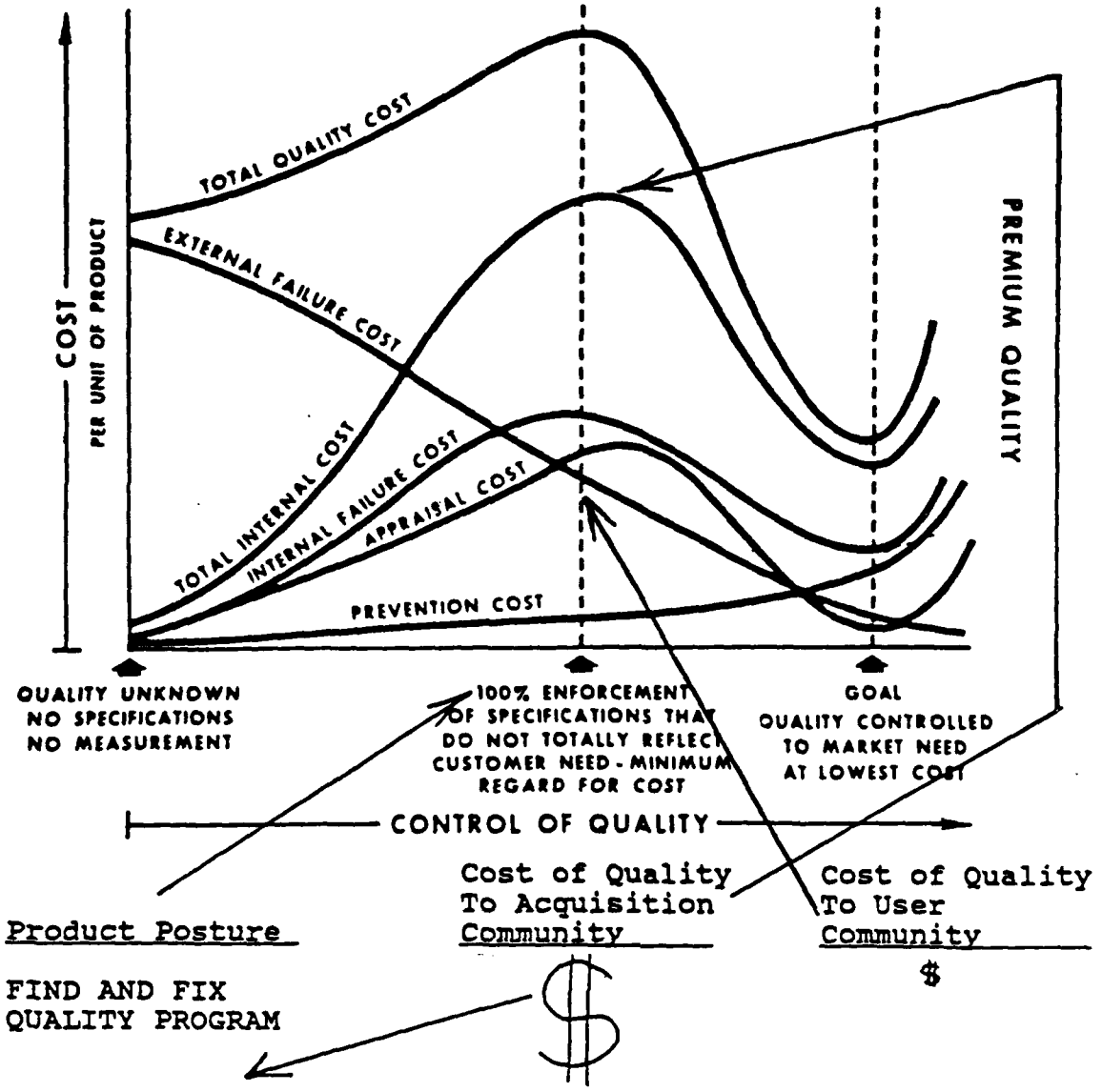


- excess O & M costs
  - extra spares
  - extra equipment
  - extra people
- low operational ready rates
- degraded mission effectiveness

Figure 1-10

It is obvious that if the manufacturer is going to expend resources to determine product quality there will be a cost associated with those resources. If the quality determination effort is eliminating field failures (other than normal wearout) then these quality efforts are satisfactory from the user's viewpoint. But how the quality effort is applied to eliminate field failures will determine to a large extent how much it costs. If the user is paying the bills, then the cost of quality is a factor in determining the end item price.

If the contractor is screening all products, at selected intermediate stages, as well as just before final delivery, and is finding and disposing of nonconforming items, then the production process is very inefficient. The process is producing defective products. If the producer knows this from experience gained through screening products, then allowances will be built in (in addition to the cost of actually doing the screening and disposing of the defects) for extra material, extra people, etc., to accommodate the scrap, rework, and repair needed to correct/eliminate the defects. All this extra allowance adds to the cost of the final product. The buyer is paying for all the inefficiency in the producer's system. The producer may have an effective quality program, based on elimination of field failures, but not an efficient quality program because he is allowing inefficient processes to generate defects and is passing along in the cost of the product the costs of finding and fixing the problems. (See Figure 1-11).



- paying for inefficiency in producers "processes"
  - materials allowance for scrap
  - consumables for rework and repair
  - extra inspectors
  - extra inspection equipment
  - extra production people for rework
  - extra people to support entire MRB program
    - engineers
    - quality technicians
    - clerks
  - extra time to redo errors
    - engineering drawings
    - purchase orders
    - bids/proposals
- "find and fix" does not prevent defects from reaching the field. Still some cost of external failures. High cost of internal failure.

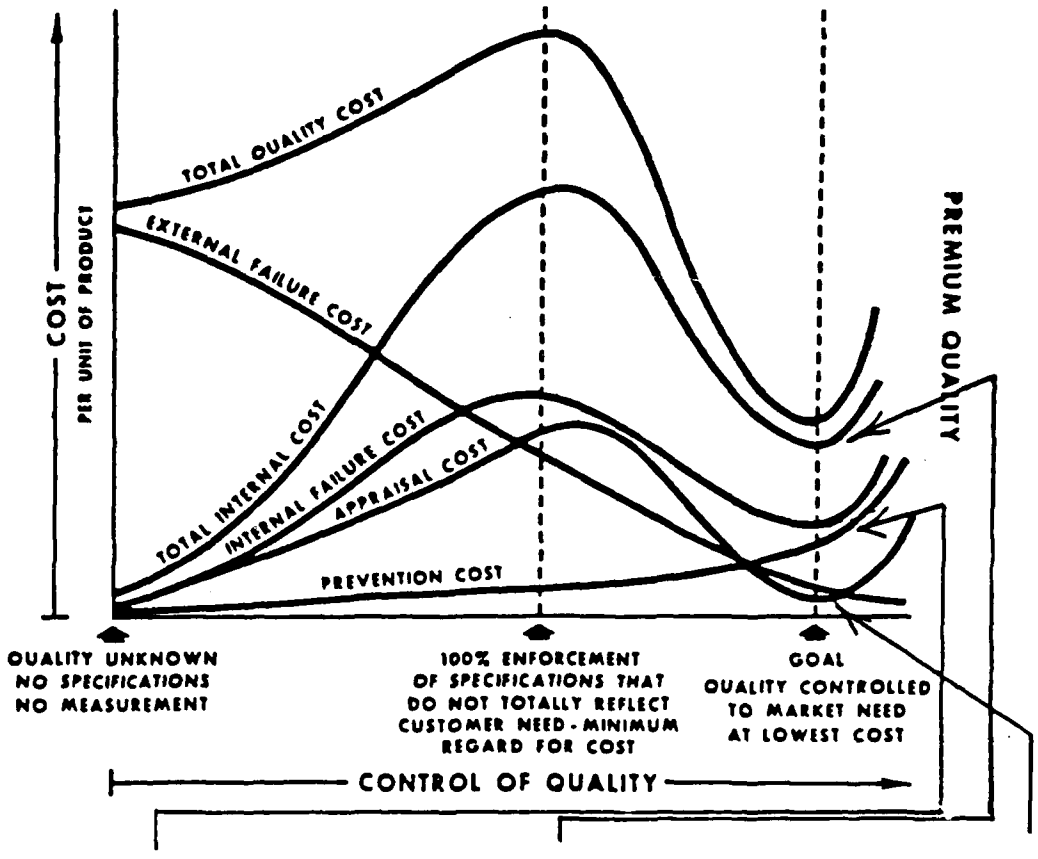
Figure 1-11

What is described above only addresses the readily visible costs associated with manufacturing. What about costs such as:

- drawing error correction
- engineering changes
- engineering liaison calls
- planning revisions
- redone purchase orders
- incomplete bid packages
- re-inspection
- re-test
- pre-review of defective material
- use as-is

All these are examples of costs associated with inefficient processes that are generating nonconforming output (engineering drawing; work instruction; purchase order) and require extra resources to correct or dispose of the nonconforming material. Once more, additional costs are generated and are passed on to the customer.

If the contractor is looking for nonconforming output and is taking steps to determine the real cause of these nonconformances, and further, is putting into place actions that not only eliminate the nonconformances, but prevent them from occurring, then he is attacking and eliminating the inefficiencies in his processes. Costs previously generated to accommodate the inefficiencies are greatly reduced or eliminated. The buyer is paying for a program that will result in effective and efficient production and on schedule delivery of a conforming product, and should not be paying for excess costs needed to support wasted resources. (See Figure 1-12).



- The optimum situation.
- Defects are <u>prevented</u> from occurring.
- Defects that do occur are found, fixed, and <u>prevented</u> from happening again.
- Assuming the design fulfills all user requirements, <u>reliability and maintainability</u> impact of defects getting to the field is greatly reduced.
- Cost of quality is low. System is both <u>effective</u> and <u>efficient</u>.

Figure 1-12

This all boils down to answering the following questions:

- Is the contractor's product failing in the field due to nonconformances?
- Is the contractor expending most of his quality costs in finding and fixing nonconformances before they reach the field?
- Is the contractor preventing nonconformances from occurring in the first place, and from recurring in the future?

See Table 1-3.

QUESTION	ANSWER YES	ANSWER NO		SITUATION/JUDGMENT
1. Is the producer's product failing in the field because of nonconformances?	X		-	Quality program is ineffective high cost to user
		X	-	Quality program may be effective, but must ask next questions to judge efficiency
2. Is the contractor expending most of his quality costs in finding and fixing nonconformances before they reach the field?	X		-	Quality program is effective, but only to the extent that most nonconformances are caught. Experience has proven that many nonconformances escape; very inefficient high cost to buyer
		X	-	Conditions in field under question 1 is "yes" or the answer to question 3 is "yes"
3. Is the contractor preventing nonconformances from occurring in the first place, and from recurring in the future, if they do occur at all?	X		-	Quality program is effective and efficient. Cost of quality to both buyer and user is low
		X	-	Conditions under question 1 or 2 above exist.

Table 1-3

Based on the above, what do we currently see as the situation with contractors building systems for the Air Force?

- The Air Force recognizes that having the user determine the quality is not a viable alternative. Therefore, we know we have some cost of quality.

- Generally we have the condition of "find and fix", or 100% enforcement of specifications.

- A small, but growing number of aerospace prime and subcontractors are adopting the "prevention" posture and are achieving effective and efficient quality programs.

- A large share of the costs are driven by the specific requirements the Air Force places on contract. (See Chapter 2, Requirements)

In order to judge whether the cost of quality is the correct cost for a contactor or for a particular program, apply the following approach:

- review contractual requirements and establish a clear understanding of what is required and what role each functional area plays.

- Determine, based on functional expert analysis, if the effort proposed by the contractor is appropriate for the stated requirement.

- Determine the cost of quality, for the company, as well as by program and by functional area.

- Examine the contractor's performance for:

    - nonconformance trends
    - repeat nonconformance occurrence
    - supplier rejects
    - repeat supplier rejects
    - field failures
    - repeat field failures
    - test results

- relative percentages for prevention, appraisal, and failure costs
- waivers/deviations
- engineering changes

- Trends are <u>much more important</u> than absolute numbers for performance indicators. (Note: ensure bases being used are not affecting the data.)

The meaning of the trend data, relative to cost of quality, must be considered. Note that high levels or "up trends" correspond to the "Quality unknown" point on the left side of figure 1-13. The "steady trend" corresponds (assuming nonconformances have fallen and are now stabilized) to the "100% enforcement" point in the center of figure 1-13. The "down trend" indicates movement along the x axis of figure 1-13, with the object being the achievement of the "Goal" point on the right side of figure 1-13. Also, keep in mind that there will be good correlation between indicators. For example, nonconformance trends and repeat nonconformance trends will <u>generally</u> be the same, although some repeat problems can exist as the more difficult problems are struggled with. The same holds true for supplier nonconformances and repeat rejects. Field failures can be caused by <u>bad design</u> as well as <u>failure to conform to the design</u>. In this case, defect rates can be low and declining, but field failures can be going up. Failures in this case are being caused by a design that fails to meet operating requirements, even though the output is made to specification. Repeat field failures are an indicator that whatever fixes, if any, are being incorporated (assuming they have reached the field) are not getting at the root cause. On the other hand, low conformance rates and high field failures can indicate that the quality system is not <u>finding</u> nonconformances that are there, and the nonconformances show up only after they cause a field failure.

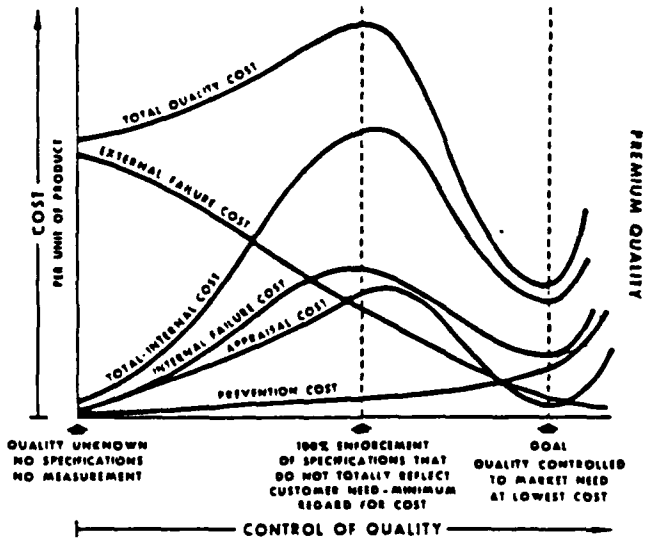


Figure 1-13

A trend for a particular indicator must be judged from a short run and a long run perspective. If, for example, a contractor is looking at data monthly, then monthly changes must be judged individually as well as over three, six, or twelve month periods. Individual changes must be looked at in context to the overall trends. Rate of change is also important. Overall level of the data is also important. Let's examine each of these situations.

In figure 1-14 we see monthly changes of 2% in each month, January through June, with a downward trend. Stability set in at approximate 3-4% for July through September. A brief upward move occurred in June, but action was taken and the trend continued downward in July. This was followed by a significant jump in October and November, not only in absolute numbers, but also the rate change. The causes here require attention. Despite the sharp drop in December, it is too early to judge whether the upward trend has been reversed. (Notice here that the category could just have easily been for purchase orders, manufacturing planning, retest, or bid and proposal rework, etc. "Rework exists throughout the organization.)

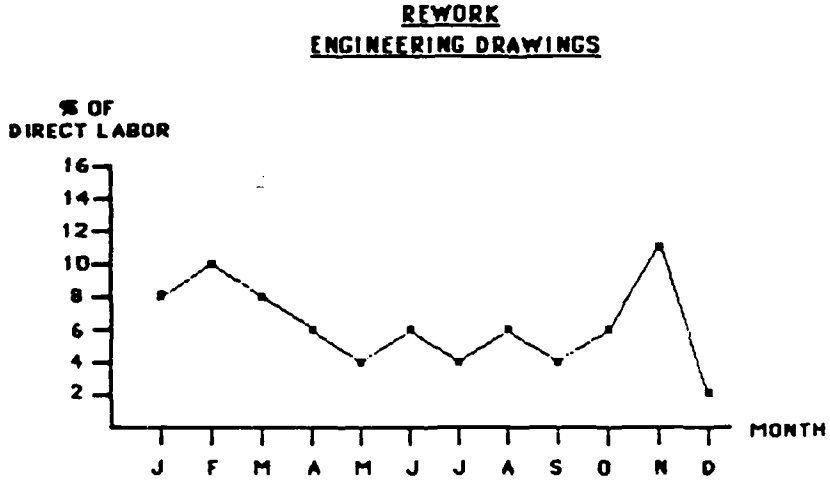


FIGURE 1-14

As an aid to looking at indicators, their trends, and their relationship one to the other, table 1-4 is provided. To use it:

- Select an indicator from the list on the left hand side, running top to bottom.
- Select a "trend direction", i.e., up, stable, or down.
- Trace across left to right and see what the other indicators, listed across the top, may show in relation to the indicator trend selected.

- Refer to footnotes when you encounter a box containing a number. The number corresponds to the applicable footnotes.

For example, if you select "nonconforming, trend up", reading across you find:

- repeat nonconformances usually are also "up"
- test failures are usually "up"
- repeat test failures are usually stable
- prevention costs in cost of quality will be low
- appraisal costs will be high
- internal failure costs will be high
- external costs will be high

Note that if you select "Defects, trend down", under "test failures" and "external failures" you have footnotes 1, 2, 3, and 4 indicated.

The point is that all the indicators must be looked at, both individually and in relation to one another, to make sound judgments as to their meaning.

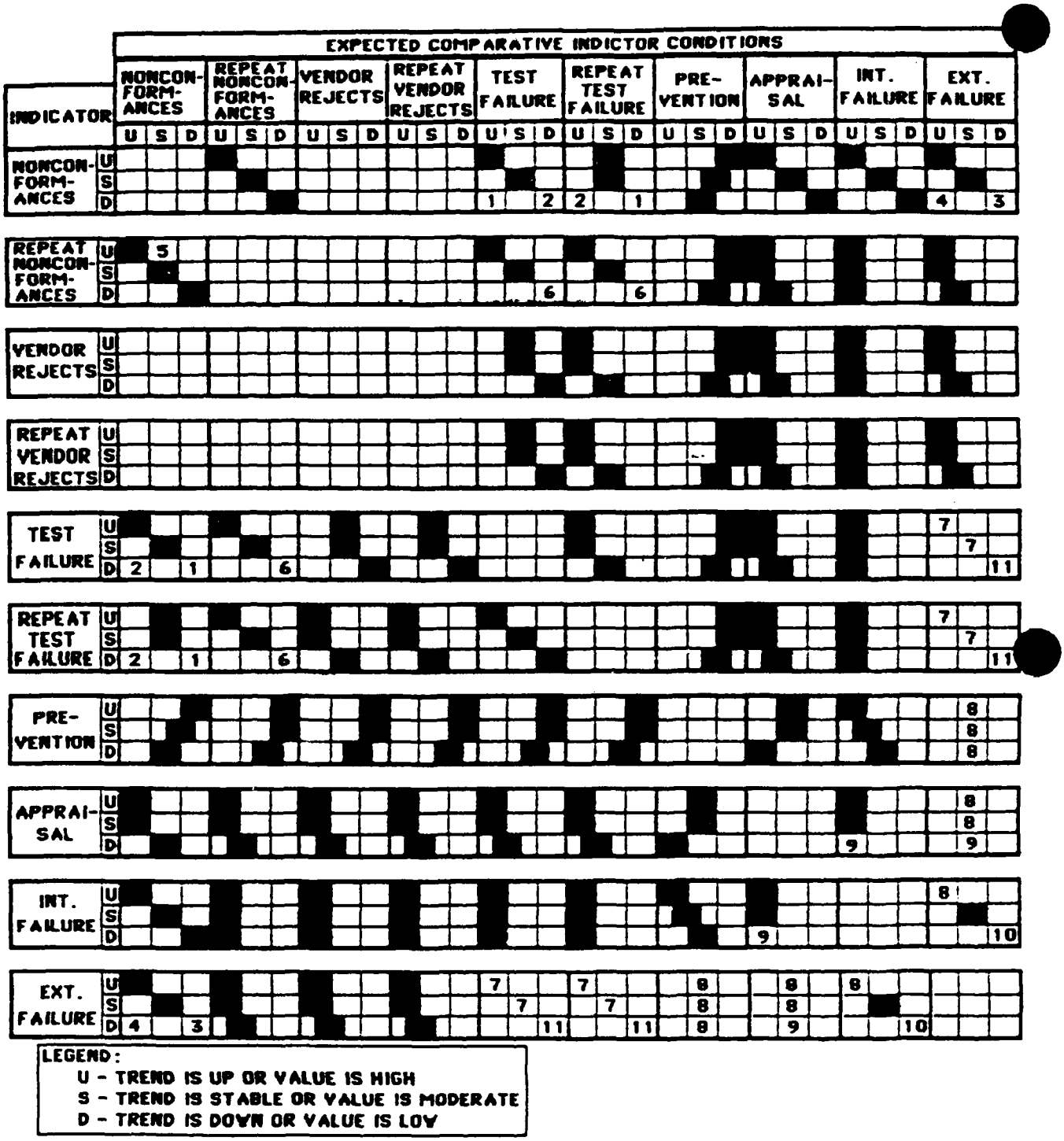

EXPECTED COMPARATIVE INDICTOR CONDITIONS
INDICATOR
NONCON-FORM-ANCES
REPEAT NONCON-FORM-ANCES
VENDOR REJECTS
REPEAT VENDOR REJECTS
TEST FAILURE
REPEAT TEST FAILURE
PRE-VENTION
APPRAI-SAL
INT. FAILURE
EXT. FAILURE
U S D
NONCON-FORM-ANCES
REPEAT NONCON-FORM-ANCES
VENDOR REJECTS
REPEAT VENDOR REJECTS
TEST FAILURE
REPEAT TEST FAILURE
PRE-VENTION
APPRAI-SAL
INT. FAILURE
EXT. FAILURE
LEGEND:
U - TREND IS UP OR VALUE IS HIGH
S - TREND IS STABLE OR VALUE IS MODERATE
D - TREND IS DOWN OR VALUE IS LOW

table 1-4

1. Could be low because nonconformances are caught before items go to test.

2. Could be high due to bad design, even through manufacturing nonconformances are caught prior to test.

3. Could be low because nonconformances are not occurring during manufacturing and those that occur are found and fixed prior to shipment.

4. Could be high due to bad design even through manufacturing nonconformances are caught prior to shipment.

5. Nonconformances trend may be stabilized, but ability to lower it can be driven by repeat nonconformances, indicating lack of correction of root cause.

6. Judged only against repeat nonconformances, test failures will probably be down.

7. Testing may be weeding out nonconformances, but more likely quality escapes are reaching the field.

8. Field failures can be controlled to a degree with the find and fix approach, but over time external failure will be at best moderate.

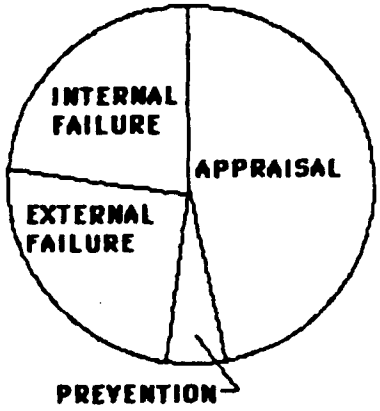
9. If appraisal is low because prevention is high (and effective) then failure may be driven more toward low.

10. Could be high if low internal failure means system is not catching nonconformances, or 2 could apply.

11. Numbers 3, 4, 7, 8, and 9 may apply.

As another aid to understanding the relationships between the categories of cost of quality and the various indicators, figure 1-15 shows three situations. As you move from the top to the bottom, the cost of quality category relationships, as a percentage of total cost of quality, change. Note that the most likely indicator conditions also change. Note also that the size of the total cost of quality gets smaller as we achieve a prevention focused condition. It is conceivable that the total could remain fairly constant. Even if this occurred, the achievement of the prevention focused condition is still providing the lowest failure rates and the highest customer satisfaction in the field.

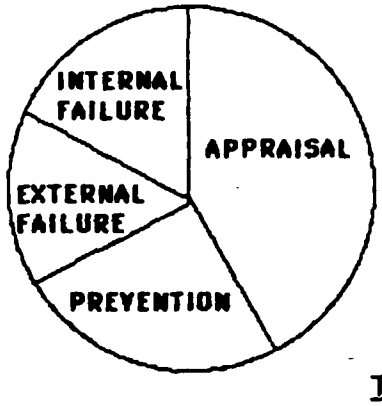
COST OF QUALITY RELATIONSHIPS



MOST LIKELY INDICATOR CONDITIONS

- NONCONFORMANCES HIGH OR RISING.
- REPEAT NONCONFORMANCES HIGH OR RISING.
- SUPPLIER REJECTS HIGH OR RISING.
- REPEAT SUPPLIER REJECTS HIGH OR RISING.
- TEST FAILURES HIGH OR RISING. COULD BE STABLE OR FALLING IF "FIND AND FIX" IS GETTING DEFECTS PRIOR TO TEST.
- REPEAT TEST FAILURES (SAME AS TEST FAILURES).

THIS IS A "FIND AND FIX" SITUATION



- NONCONFORMANCES STABLE OR BEGINNING TO DECLINE. (ASSUMES PREVENTION EFFORT IS EFFECTIVE)
- REPEAT NONCONFORMANCES STABLE OR BEGINNING TO DECLINE.
- SUPPLIER REJECTS STABLE OR BEGINNING TO DECLINE. POSSIBLE THAT ALTHOUGH INTERNAL QUALITY IS STARTING TO IMPROVE, EFFORTS WITH SUPPLIERS ARE STILL LACKING.
- REPEAT SUPPLIER REJECTS (SAME AS SUPPLIER REJECTS).
- TEST FAILURES STABLE OR BEGINNING TO DECLINE. ASSUMES DESIGN IS GOOD.
- REPEAT TEST FAILURES (SAME AS TEST FAILURES).

THIS IS A "SWITCH TO PREVENTION" SITUATION

- NONCONFORMANCES ARE LOW, HAVE BEEN AND ARE CONTINUING TO DECLINE.
- REPEAT DEFECTS NONCONFORMANCES ARE ALMOST NON-EXISTENT.
- SUPPLIER REJECTS ARE LOW, HAVE BEEN AND ARE CONTINUING TO DECLINE. IT IS POSSILBE, BUT EXTREMELY UNLIKELY, THAT SUPPLIER REJECTS ARE STILL A PROBLEM. ONCE THE VALUE OF STRONG INTERNAL PREVENTION IS RECOGNIZED, IT IS EMPHASIZED WITH SUPPLIERS.
- REPEAT SUPPLIER REJECTS (SAME AS SUPPLIER REJECTS).
- TEST FAILURES ARE VERY LOW AND DECLINING.
- REPEAT TEST FAILURES ARE ALMOST NON-EXISTENT.
- APPRAISAL REMAINS A LARGE PERCENTAGE, BUT NOW THE FOCUS IS ON AUDIT OF ALL COMPANY QUALITY "SYSTEMS", NOT "FIND AND FIX

THIS IS A PREVENTION FOCUSED CONDITION

figure 1-15

COST OF QUALITY-REQUIREMENTS

1. A question often exists in many people's minds concerning just what legal or binding requirement exists that forms the basis for cost of quality collection and reporting. While it is generally recognized that MIL-Q-9858A contains a specific reference to cost of quality, there are many other requirements, based in regulation and law, that flow from the executive and legistlative branches down to the contractor. What follows is a discussion of these various requirements. Tax-payers demand cost-effective military systems and reliable performance throughout the acquired system's life cycle. The citizens carry their views to their government representatives in Congress to ensure defense dollars are cost-effective. The Congress of the United States of America uses its legislative powers to pass laws, and to appropriate monies for the goods and services needed to operate the government. The Executive branch of government is responsible for implementation of the laws and expenditure of funds as authorized.

2. In the case of federally acquired goods and services the Office of Management and Budget (OMB) through its Office of Federal Procurement Policy (OFPP) issues the Federal Acquisition Regulations (FAR'S) which govern the acquisition of all federal goods and services. FAR part 46 addresses Quality Assurance requirements. (Figure 2-1)

The following are several key requirements spelled out in the FAR part 46, involving Quality:

> "Agencies shall ensure that contracts include inspection and other quality requirements . . .
>
> that are determined necessary to protect the government interest."
>
> "The contractor is responsible for carrying out its obligation under the contract."
>
> "Agencies shall ensure that nonconforming supplies or services are rejected, except as otherwise provided in 46.407."

Far 46.407 nonconforming supplies or services is quoted in its entirety for emphasis and better understanding. Underlining is for emphasis!

FLOWDOWN OF LEGAL BASIS FOR COST OF QUALITY

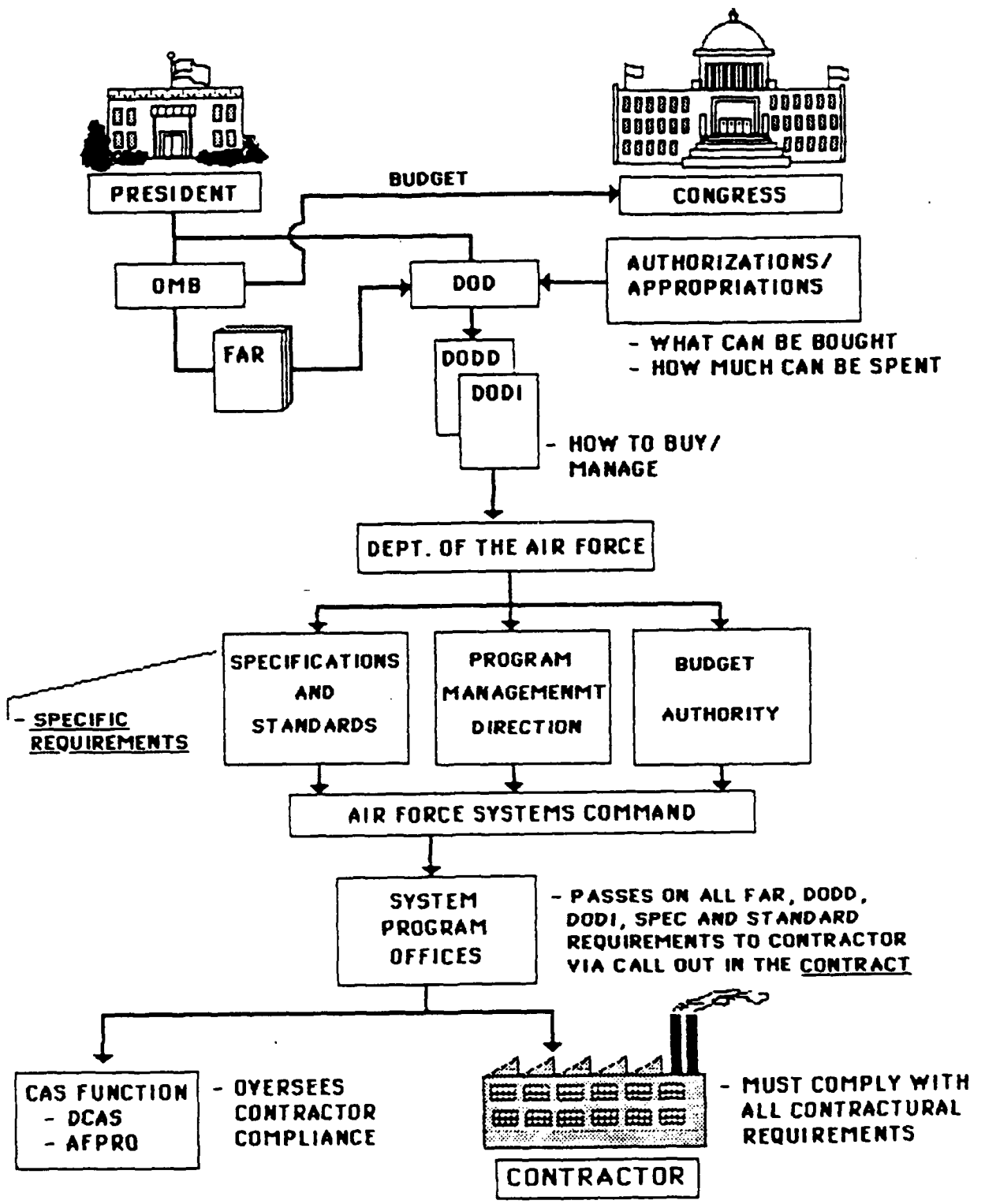


Figure 2-1

(a) Contracting officers should reject supplies or services not conforming in all respects to contract requirements (see 46.102). In those instances where deviation from this policy is found to be in the Government's interest, such supplies or services may be accepted only as authorized in this section.

(b) Contractors ordinarily shall be given an opportunity to correct or replace nonconforming supplies or services when this can be accomplished within the required delivery schedule. Unless the contract specifies otherwise (as may be the case in some cost-reimbursement contracts, correction or replacement shall be without additional cost to the Government. Subparagraph (e)(2) of the clause at 52 246-2. Inspection of Supplies-Fixed-Price, reserves to the Government reinspection and retests because of prior rejection.

(c) (1) In situations not covered by (b) above, the contracting officer shall ordinarily reject supplies or services when the nonconformance adversely affects safety, health, reliability, durability, performance, interchangeability of parts or assemblies, weight or appearance (where a consideration), or any other basic objective of the specification. However, there may be circumstances (e.g., reasons of economy or urgency) when acceptance of such supplies or services is determined by the contracting officer to be in the Government's interest. The contracting officer shall make this determination, based upon-

(i) Advice of the technical activity that the material is safe to use, and will perform its intended purpose;

(ii) Information regarding the nature and extent of the nonconformance;

(iii) A request from the contractor for acceptance of the supplies or services (if feasible);

(iv) A recommendation for acceptance or rejection, with supporting rationale; and

(v) The contract adjustment considered appropriate, including any adjustment offered by the contractor.

(2) The cognizant contract administration office, or the Government activity directly involved, shall furnish this data to the contracting officer in writing. Except that in urgent cases, it may be furnished orally and later confirmed in writing. Before making a decision to accept, the contracting officer shall obtain the concurrence of the activity responsible for the technical requirements of the contract, and where health factors are involved, of the responsible health official of the agency concerned.

(d) If the nonconformance is minor, in that it does not affect any of the factors referred to in (c) above, the cognizant contract administration office may make the determination to accept or reject, except where this authority is withheld by the contracting office of the contracting activity. To assist in making this determination, the contract administration office may establish a joint contractor-contract administrative office review group. Acceptance of nonconforming supplies that affect any of the factors referred to in (c) above is outside the scope of the review group and must be handled as specified there.

(e) Contracting officers shall discourage the repeated tender of nonconforming supplies or services, including those with only minor nonconformances, by appropriate action, such as rejection and documenting the contractor's performance record.

(f) Each contract under which nonconforming supplies or services are accepted as authorized in (c) above shall be modified to provide for an equitable price reduction or other consideration. However, when supplies or services involving minor nonconformances are accepted, the contract shall not be modified unless (1) it appears that the savings to the contractor in fabricating the nonconforming supplies or performing the nonconforming services will exceed the cost to the Government of processing the modification, or (2) the Government's interests otherwise require a contract modification.

(g) Notices of rejection shall include the reasons for rejection and be furnished promptly to the contractor. Promptness in giving this notice is essential because, if timely nature of rejection is not furnished, acceptance may in certain cases be implied as a matter of law. The notice shall be in writing if-

(1) The supplies or services have been rejected at a place other than the contractor's plant;

(2) The contractor persists in offering nonconforming supplies or services for acceptance; or

(3) Delivery or performance was late without excusable cause.

3. The Office of the Secretary of Defense (OSD) is responsible for implementation of the FAR'S within the Office of the Secretary of Defense (OSD) and its Department of Defense (DOD) components. This is accomplished through policies contained in Department of Defense Directives (DODD's) and Department of Defense Instructions (DODI's).

Acquisition actions and techniques to obtain cost effective integration are addressed in the entire series of DODD's and DODI's as well as DOD specifications, standards, regulations, manuals and pamphlets. For example; DODD-5000.1 "Major and Non-Major Defense acquisition Programs, September 1, 1987 and DODI-5000.2 "Defense Acquisition Program Procedures," September 1, 1987 require cost visibility and consideration at milestone/decision points throughout the acquisition process.

The DODD 4155.1, "Quality Program", August 10, 1978, establishes five specific objectives, one of which requires assurance that the other four objectives are cost effective. The DODD 4245.6 "Defense Production Management", January 19, 1984 states it is DOD policy to plan for production early in the acquisition process and to integrate acquisition actions to ensure an orderly transition from development to cost-effective rate production."

Quality history which includes "quality costs" are evaluated as a function of the source selection process. Recently, some solicitation packages have been including a requirement for a Quality Improvement Plan which includes anticipated Cost Of Quality improvements.

A key specification is MIL-Q-9858A "Quality Program". Paragraph 3.6 "Costs Related To Quality", is quoted here in its entirety with underlining for emphasis.

> "3.6 Costs Related to Quality. The contractor shall maintain and use quality cost data as a management element of the quality program. These data shall serve the purpose of identifying the cost of both the prevention and correction of nonconforming supplies (e.g., labor and material involved in material spoilage caused by defective work, correction of defective work and for quality control exercised by the contractor at subcontractor's or vendor's facilities). The specific quality cost data to be maintained and used will be determined by the contractor. These data shall, on request, be identified and made available for "on site" review by the Government Representative." (See Amendment Number Two, dated 8 March 1985.)

CURRENT GOVERNMENT FOCUS

Discussion with government personnel currently involved in performing cost of quality audits revealed that the concentration has been solely on the FAILURE cost area. The explanation given is that failure cost is the only contractual requirement for cost of quality that currently exists in MIL-Q-9858A, paragraph 3.6 and 6.5, which talk to "cost of quality" and " . . . correction of failures." It is the opinion of the authors of this handbook that this interpretation falls short of what is required of contractors by MIL-Q-9858A.

Paragraph 3.6 specifically states PREVENTION costs are required to be maintained. Now refer to paragraph 3.5 of MIL-Q-9858A:

> "3.5 Corrective Action. The quality program shall detect promptly and correct assignable conditions adverse to quality. Design, purchasing, manufacturing, testing or other operations which could result in or have resulted in defective supplies, services, facilities, technical data, standards or other elements of contract performance which could create excessive losses or costs must be identified and changed as a result of the quality program. Corrective action will extend to the performance of all suppliers and vendors and will be responsive to data and product forwarded from users. Corrective action shall include as a minimum:
>
> a. Analysis of data and examination of product scrapped or reworked to determine extent and causes;
>
> b. Analysis of trends in processes or performance of work to prevent nonconforming product; and,
>
> c. Introduction of required improvements and corrections, an initial review of the adequacy of such measures and monitoring of the effectiveness of corrective action taken.

Wording under 3.5 (b) is specific to PREVENTION. General wording covers APPRAISAL and FAILURE. These are clear, direct requirements of the quality program. The costs associated with these must be captured. Paragraph 3.6 calls for cost of prevention. Corrective action costs are part of failure.

Now look at paragraph 3.4:

> "3.4 Records. The contractor shall maintain and use any records or data essential to the economical and effective operation of his quality program. These records shall be available for review by the Government Representative and copies of individual records shall be furnished him upon request. Records are considered one of the principal forms of objective evidence of quality. The quality program shall

assure that records are complete and reliable. Inspection and testing records shall, as a minimum, indicate the nature of the observations together with the number of observations made and the number and type of deficiencies found. Also, records for monitoring work performance and for inspection and testing shall indicate the acceptability of work or products and the action taken in connection with deficiencies. The quality program shall provide for the analysis and use of records as a basis for management action.

Here again, APPRAISAL is covered by the requirement to maintain records of all appraisal activity. FAILURE is covered again by reference to action taken in connection with deficiencies (failures and their disposition). Additional wording appears under paragraph 1.3, Summary:

"The program shall facilitate determinations of the effects of quality deficiencies and quality costs on price."

"All supplies and services under the contract, whether manufactured or performed within the contractor's plant or at any other source, shall be controlled at all points necessary to assure conformance to contractual requirements. The program shall provide for the prevention and ready detection of discrepancies and for timely and positive corrective action. The contractor shall make objective evidence of quality conformance readily available to the Government Representative. Instructions and records for quality must be controlled.

Paragraph 6.5 is specific relative to costs:

"The contractor shall make known to the government upon request the data associated with the costs and losses in connection with scrap and with rework necessary to reprocess nonconforming material to make it conform completely."

Strict interpretation limits the basis for cost of quality audit requirements to paragraph 3.6 (see page 2-6) under failure only, and paragraph 6.5 misses the other clear requirements in MIL-Q for capture and use of PREVENTION and APPRAISAL costs, as well as all types of FAILURE, not only scrap and rework of material. The suggested contractual clauses contained in chapter four are designed to get at what is already required. Whether these or similar type clauses are adopted, MIL-Q-9858A clearly covers all cost of quality in its present form.

OTHER REQUIREMENTS

Another key standard involving costs of quality is MIL-STD-1520C, "Corrective Action And Disposition System For Nonconforming Material," 27 June, 1986. The primary purposes of the system are to identify and correct causes of nonconformances, prevent recurrence of wasteful nonconforming material, reduce the cost of manu-

facturing inefficiency, and foster quality and productivity improvement."

MIL-STD-1520C Paragraph 5.7.4 Nonconformance costs, states "The contractor shall determine and record the costs associated with nonconformances. The objective of generating the cost data is to provide current and trend data to be used by the contractor in determining the need for and effectiveness of corrective action. The resultant cost data shall serve as a basis for necessary Corrective Action Board (CAB) and Quality Improvement Project (QIP) action when appropriate. Nonconformance cost summaries shall consist of scrap, rework, repair, use-as-is, and return to supplier costs, plus other costs as determined appropriate by the contractor."

Minimum data summarization requirements in MIL-STD-1520C paragraph 5.8 include all costs described in paragraph 5.7.4 of MIL-STD-1520C. Preparation of the required data shall not be less frequent than quarterly. The contractor shall periodically ensure, both in-house, and at suppliers where appropriate, that audits are conducted of MIL-STD-1520C requirements to verify compliance and ensure effectiveness. Nonconformance costs are included in these audits.

The Defense Logistics Agency (DLA), who administers many DoD contracts, issued change 4 to DLAM 8200.2. This change was "designed to assure uniformity of program application and performance of required Defense Contract Administration Services (DCAS), Quality Assurance (QA) functional responsibilities." This change also included guidelines which helped to identify the types of costs generally included in the COQ categories of Prevention, Detection/Assessment and Failures. DLAR 8200.10 "Control of Nonconforming Material", 8 June 1987 reflects an increasing effort by the government to control and reduce nonconformance costs. Under the authority of FAR 46-407 the government sent a signal to contractors with DLAR 8200.10, which provides a means to transfer nonconformance costs back to the contractor. This indicates the government intends to enforce FAR 46.407 and will no longer accept what it considers to be excessive major or minor nonconformance of product.

The aforementioned requirements can be affected by the type of contract written, priorities within the contract, and flow-down of requirements to suppliers.

Other contractual requirements and standards such as MIL-STD-1535A, MIL-STD-1528A, and MIL-STD-1567A (especially variance analysis requirements) involve cost of quality requirements (details provided under functional sections 4-5, and 4-3). Additionally, many other requirements exist that are cost effective issues involving quality: design to cost, life cycle cost, logistics support analysis, reliability, maintainability, producibility, value engineering, pre-planned product improvements, industrial modernization improved methods and processes, functional/physical configuration audits, production readiness reviews, work measurement, cost/schedule reports, cost in time for the cognizant CAO to direct

remedial corrective actions, process requirements, electronic stress screening, workmanship practices, training - testing - inspection, purchase orders, failure reporting and corrective action system (FRACAS), equipment - facilities - resources, material, procedures - instructions, shop practices, material shortage, out of station work, schedule not realistic, engineering drawings (detail) late/changes, lack of tooling, planning/changes not well coordinated, qualification of suppliers, bill of material shortfalls, and inaccurate records.

Noncontractual agreements are also used by some agencies to establish COQ goals and commitments when contractual requirements cannot be negotiated.

There are a wide variety of professional organizations that establish National Consensus Standards or Programs which are extremely valuable but are not contractual requirements. For example, the American Society of Quality Control (ASQC) has published many books and articles that define quality costs and explain why quality costs are important and how to control them. Additionally, the National Association of Accountants recently published a book entitled "Measuring, Planning, and Controlling Quality Costs". Chapter one, Figure 1 and Appendix B of this handbook provide copies of the cost of quality items these professional organizations have identified as applicable and useful in most cases.

The requirements for quality cost systems have existed for many years as a means of highlighting the cost of poor planning and performance, that is, the cost of <u>not</u> doing things right the first time. However, these systems have not been well understood due to problems with definition and application to specific management tasks, specific job tasks, and various functional areas of responsibility.

An adequate definition of quality cost exists today. The government must grasp what is available, adopt a standard definition of quality cost categories, build contract requirements that are flexible, yet adequately integrate all cost-effective efforts including the COQ requirements, and develop better systems for documenting, measuring, controlling, and reporting costs that achieve the desired quality in on-schedule delivery of goods and services.

The program management office is the key to obtaining the integration of <u>all factors</u> during the acquisition process and to ensure reasonable and cost effective COQ requirements exist in the negotiated contract. The contractor must comply with contractual requirements by planning and implementing systems that control cost of quality. The suggested cost of quality contractual clauses provided in Chapter five provide ideas on ways to get what the government wants.

3-1 METHODOLOGIES - GENERAL

Cost of Quality can be a key management tool. It is not a solution in itself, but rather a major tool to measure progress or lack thereof over time. But, how is cost of quality, that is, the cost of prevention, appraisal, and of failure, found?

Just as quality or excellence is everyone's responsibility, quality costs are accrued by every one. Consequently, they are within the ability of everyone to identify and impact, to a greater or lesser degree. If it is true that "what gets measured, gets done", a measurement of cost is the first step toward management and control of cost of quality, to the benefit of the consumers, producer, and suppliers.

Earlier, the reader was introduced to cost of quality definitions and categorization into prevention, appraisal, and failure costs. These same categories should be used to quantify costs.

We can measure cost of quality in many ways, depending on the category being considered. For example, failure:

Cost of nonconforming units

Mass of material nonconforming

Number of ECNs

or, Incorrectly prepared P.O.s

But only by costing all these expenses can we develop a true picture of the impact of cost of quality to the organization. By comparing these costs to other performance and financial data, opportunities for cost reduction and enhancement of material quality can be pinpointed. Most importantly, the user in the field will benefit as well as the producer. Make no mistake, there is no trade off here. A conforming, quality product can be delivered to the user and the producer can still cut his cost significantly. Recall the company example in Chapter one.

As an enterprise or organization develops towards excellence, more of the cost of quality shifts to prevention costs. Such an organization embraces preventative principles, and high quality products and services become the result of thousands of mini-scale efforts and decisions over time. Measuring the cost of quality and comparing its development over time allows for appraisal of the many

efforts and decisions. The only real purpose for developing the cost of quality is to develop a keen understanding of where process and product improvement, cost reduction, and quality enhancement can be achieved, so as to serve the users interest equally well or better (Chapter one, Benefit #1 and #2). Developing data into useful information and using that information for decision making is the goal. Information is power. Sharing the cost of quality information allows not only quality assurance professionals, but managers in all areas to study processes and operations and take actions designed to eliminate waste and unnecessary effort, and promote the concept of "doing it" right the first time.

But where do we find costs of quality and types of activities that generate these costs? Once identified, how do we express the costs in a meaningful manner and what purpose will this data serve?

As mentioned earlier, costs of quality are found in all areas of the typical organization:

Finance and Accounting

Human Resources

Materials Management

Manufacturing

Engineering

Distribution

Marketing

Customer and Field Service

As explained in Chapter one, cost of quality should be divided into the categories of Prevention, Appraisal, Internal Failure, and External Failure. The listing of examples in Table 1-1 is taken from "Principals of Quality Costs" published by ASQC (See also, Appendix A). Although these represent thorough listings of cost of quality possibilities, few organizations will use exactly the same categories. Many items can be added as they are uniquely suited to a particular contractor and some may be deleted as inconsequential or not necessary.

Approaches will vary from contractor to contractor. For example, in many systems capital costs will not be measured. Capital costs would include such items as floor space and capital equipment, as well as the associated depreciation. Also, indirect costs may be omitted. Indirect costs may include costs such as customer costs associated with

external failure which are not reimbursed by the contractor, interests costs (or cost of money) for excess inventories, vendor quality costs affecting the contractor (the absence of which would reduce product or service cost to the contractor), overhead costs for production of internal failures, etc.

Basic Cost of Quality Structure

The most basic of quality cost systems should certainly include the following:

- Prevention
  a. The quality organization costs except for inspection, testing, and failure efforts.
  b. New product testing and design efforts.
  c. Q training
  d. Supplier reviews and audits
- Appraisal
  a. All inspection, internal and external
  b. Quality data and information development and analysis
  c. Outsourced product or service evaluation and control programs.
  d. Product reliability testing
  e. Inspection and test equipment and supplies
- Internal Failures
  a. Scrap
  b. Rework, repair, use as-is
  c. Failure analysis
  d. Engineering changes
  e. Purchase order changes
  f. Design re-evaluation

- External Failures

  a. Warranty Costs

  b. Returned goods

  c. Product Liability Insurance

All of these basic costs of quality should be available through the standard accounting system. The controller or contractor financial contact should be able to supply these costs in a relatively accurate fashion.

Role of Controller Function

Proactive participation by the contractor's accounting or financial representatives will benefit in achieving the most accurate development of a total quality cost. It must be remembered that the cost of quality is a portion of the total quality program. Cost of Quality really defines the entire quality system, in terms of dollars. The cost of quality should not be used as simply a cost cutting tool. Comparisons to previous performance over time is the primary purpose for the cost of quality (Chapter 1, Benefit #5). Comparison to other firms or divisions tends to be inaccurate and misleading because of the fact that accounting data are gathered and reported differently in various organizations and enterprises, product lines differ, and management approaches vary a great deal.

The quality costs are to be found in many areas. It is at this point that the Quality department personnel and accounting personnel must interact. The quality person is primarily responsible for the accounting of nonconformances and errors. It is the controller and accounting personnel who are responsible for assigning dollar values and costs to the quality effort. Together, they must bring the rest of the organization under the total cost of quality umbrella.

Incorporating the responsibility for cost of quality with the comptroller allows functions across all departments in the company to participate. In addition, the costs reported will tend to have more credibility because they come from the same source as all other financial data for the company.

Sources for Costs of Quality

Most of the cost of quality can be found in the following sources:

Contractual Requirements

In the event that government contracts for goods or services are involved, certain quality requirements may be part of the contract purchase agreement (e.g., various military specifications, MIL-Q-9858A, MIL-STD-1520C, MIL-STD-1535A, MIL-STD-1567A, Environmental Test Screening, FRACAS, etc.) Review of these contractually required documents will provide a basis for then going to the responsible function to find costs associated with these quality program requirements.

Chart of Accounts and General Ledger

In the chart of accounts one will find the basic explanation of all accounts, systematically arranged, applicable to a specific enterprise or organization. Figure 3-1 provides an example of a typical chart of accounts. The example is not all inclusive.

The general ledger will list all detailed or summarized transactions for the business. In using this source, it will be necessary to seek guidance from finance or pricing personnel. Many costs of quality will be included in other costs posted to the general ledger. It will be necessary to make estimates or complete further investigation to establish many costs. Keep in mind that estimates may be required, and it is far better to use estimates which are made on an informed basis than to ignore the cost.

Business Plan and Budget

This document will provide information concerning indirect, support and staff efforts, and types of costs of quality. For example, all costs for returned goods, warranty, and field service should be External Failure costs and recorded on the quality cost report accordingly. Training costs should be appropriately accounted as prevention costs. In some cases departmental or function operation (i.e., engineering, manufacturing) budgets will contain more detail than the corporate business plan and/or budget. Referring to these documents is a logical next step.

The operating budget should give you a reasonably complete listing of expense by account and category.

ABC COMPANY

CHART OF ACCOUNTS

7-1-88

ACCOUNT NUMBER	ACCOUNT DESCRIPTION
100	Salary
200	Hourly General
201	General Indirect
202	Trucking
203	Inspection
300	Hourly Maintenance
301	Mech. & Ele. Repair
302	Die & Jig Repair
303	Janitorial
400	Premium Pay
500	Hourly Fringe Benefits
501	Vacation & Holidays
502	FICA
503	Welfare
504	State Employment Ins.
505	Fed. Employment Ins.
506	Workmens Compensation
600	Salary Fringe Benefits
700	Operating Supplies
701	Factory
702	Janitorial
703	Perishable Tools
704	Medical
705	Medical
800	Maintenance Supplies
801	Mech. & Elec. Repair
802	Die Repair
803	Building Repair
900	Utilities
901	Gas & Oil
902	Electric
903	Telephone
1000	Nonconforming Material
1001	Returned Goods

Figure 3-1

Existing C.O.Q. Statement or Reports

Many organizations already have cost of quality programs developed to some level, but as discussed in Appendix B "Survey Results", most concentrate on failure costs. These reports can add valuable information and data. A clear understanding of the data should be obtained so that costs included in this data are not duplicated or assumed and not stated in other areas. Nonconformance data will nearly always be available in these reports and will significantly support cost of quality in the manufacturing area.

Labor Reporting Statements

In many cases, a separation of appraisal or inspection time versus standard operations time will be provided. In many others, however, it will be necessary to establish estimates for appraisal cost involved in direct labor efforts. (See Analytical Techniques in this chapter.) If the contract calls for MIL-STD-1567A, Work Measurement, then data should be available (See also Chapter five, page 2).

Capital Equipment Listing and Calibration Logs

Appraisal equipment costs and user groups can be identified from these sources. Calibration logs and reports will reside with the Q.A. personnel and appraisal inspection Capital Equipment will be located with O.H. and/or Finance.

Customer Service - Field Service Reports

Returned goods, warranty costs, and field service costs can be found in these reports which will substantially impact the External Failure Costs of Quality.

Interviews and Operation Reviews

In many cases, without benefits of hard cost data, it will be necessary to estimate certain costs of quality. This is an accepted method of determining costs of quality and in most cases, supervisors and involved engineering personnel have accurate data on which to make assumptions and estimates. In other circumstances it may be advisable to review the process concerned and to

develop costs based on the effort actually involved.

The technique provided later in this chapter represents a format that might be used for such a review process.

Summarizing the Cost of Quality

When the data has been obtained or developed and each cost has been defined as a prevention cost, appraisal cost, internal failure cost or external failure cost, the costs should be summarized and presented as a Cost of Quality Report. Any organized and traceable format can be used, such as the example listed in Figure 3-4. This data can then be used to develop trend analysis to measure the improvement of product service quality over time. An example of a cost of quality summary report is shown in Figure 3-4.

COST ACCOUNTING APPROACHES

In terms of the methodologies used by the contractor to account for costs, understanding the approach used will enable an Air Force evaluator to find the cost of quality within that accounting technique. Keep in mind that actual visibility of or access to the detailed numbers may be limited by type of contract and what, if any, cost reporting requirements have been put in place.

As mentioned in Chapter five under "Verification and Audit", contracts with formal cost and schedule reporting provide accounting basis stemming for work packages and planning packages, as well as cost accounts. Again, recall that direct costs are covered here, but not indirect. A majority of the costs associated with cost of quality will be indirect costs.

Cost Centers - usually an area in which a single, distinguishable type of operation or function is performed. Cost centers are typically divided further, based on the type of activity performed.

- Productive Cost Centers - specific work done, directly traceable to the product.
- Service Cost Centers - individual activities that support productive activities, but are not obviously traceable to a specific product. These are normally classified as indirect costs.

Cost accounting systems are usually found to be one of two basic types. There are the Job Order and Process Cost Systems. Both can be either a historical cost system or a predetermined cost system. Neither approach is applied in its "pure" form, but more typically is modified to suit the particular contractor's method of managing his business.

Under the job order cost approach, costs will normally be accumulated by jobs, lots, or orders. Workers will identify on their time cards the jobs on which they work, and a calculated overhead rate is then applied. Under the process cost approach, costs will normally be accumulated by units of product within each process or department. Total costs for producing a kind of unit and the number of that kind of unit produced are determined for regular accounting periods. Then an average cost for the period is determined.

The vast majority of Air Force programs will fall in the job order cost area.

Another approach involves the use of a Historical Cost System. The job order cost approach can also be called a historical system if the only data about an end products' production are accumulated after the end product is produced. Historical data are used in all cost accounting systems, at least as a basis for comparing actual results to predicted results. The reporting under C/SCSC, which looks at budgeted cost of work performed versus actual cost of work performed, is using the historical approach. When a contractor uses historical costs as a basis for projecting what the future costs will be, it is important to understand that many cost of quality elements, and their associated costs, are driven by the phase of the program. Table 3-1 shows a breakout by major functional area as to when various actions that comprise typical cost of quality items occur for each phase of the acquisition process. Note that the detailed information provided in each functional section in Chapter four can be used in conjunction with Table 3-1 and, when combined with judgement, provide a good basis for determining exactly when (by phase) a particular cost of quality can be expected to occur.

Closely related to the phase of the program is the recurring and nonrecurring aspect of many costs. Recurring costs are those which will be incurred over and over again during the life of the program. Examples of recurring costs are:

- production material
- production labor
- ST/STE repair/maintenance
- expendable tools (drill bits, cutting/machine tools, etc.)

Nonrecurring costs are those that will be incurred as a one time effort, and are expended, will not be repeated. Examples are:

- design and manufacture of special tools/test equipment
- plant rearrangement
- tooling (jigs; fixtures)
- operating instructions

The analyst should be sure to consider whether a proposed cost is recurring or nonrecurring, and whether it has been properly proposed and would be expected to occur in the phase of the program being considered.

The last approach that bears mentioning is the Predetermined Cost System approach. These type systems accummulate data about the production of an end product before the end product is produced. Cost estimating techniques are used by the contractor to predict his costs for doing a particular job.

FUNCTION	CON. DEVEL.	VALIDATION	FSD	PRODUCTION	DEPLOYMENT
PROGRAM MANAGEMENT	**PREVENTION** CONSIDER CONTRACTUAL REQ'TS →	→	→	→	
		PREVENTION PLAN/EXECUTE RISK MGMT →	→	→	
	APPRAISAL -REVIEW/UPDATE PROG. PLANS →	→	→	→	
	-CONDUCT PROG. REVIEWS →	→	→	→	→
	FAILURE ACTION TO CORRECT NONCONFORMANCES →	→	→	→	→
	- PLANNING - EXECUTION				
SYSTEMS ENGINEERING	**PREVENTION** -ENSURE CUSTOMER REQ'TS ARE CLEARLY UNDERSTOOD →	→	→	→	→
	-DEVELOP TRADE STUDIES →	→			
	-ENSURE PRODUCIBILITY →	→	→	→	
	-ENSURE INSPECTABILITY →	→	→	→	
	-ENSURE TESTABILITY →	→	→	→	
	(NOTE: ALL THE ABOVE FOR HARDWARE & COMPUTER SOFTWARE)	**APPRAISAL** DESIGN REVIEWS →	→	→	
		PREVENTION FMEA →	→		

Table 3-1

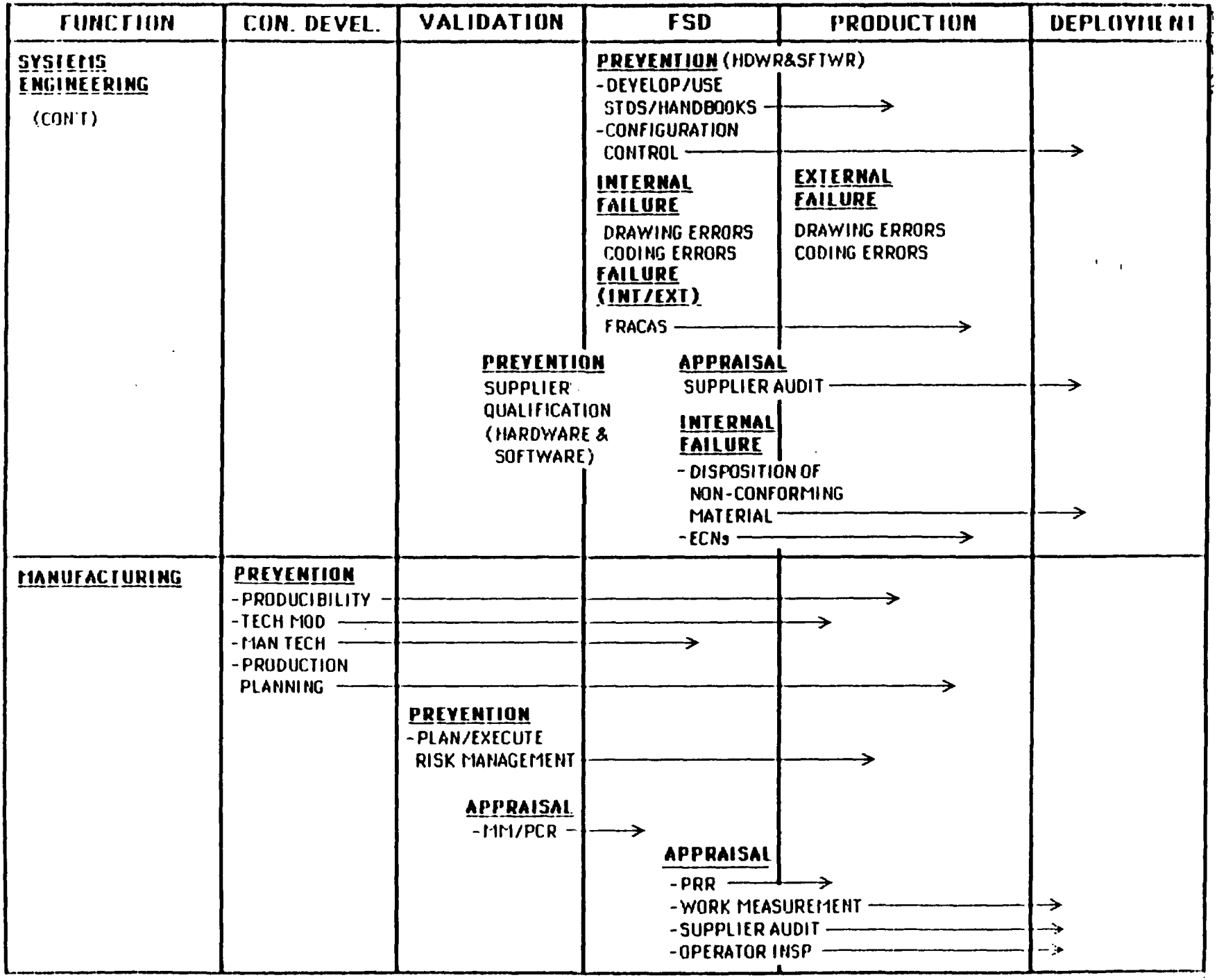
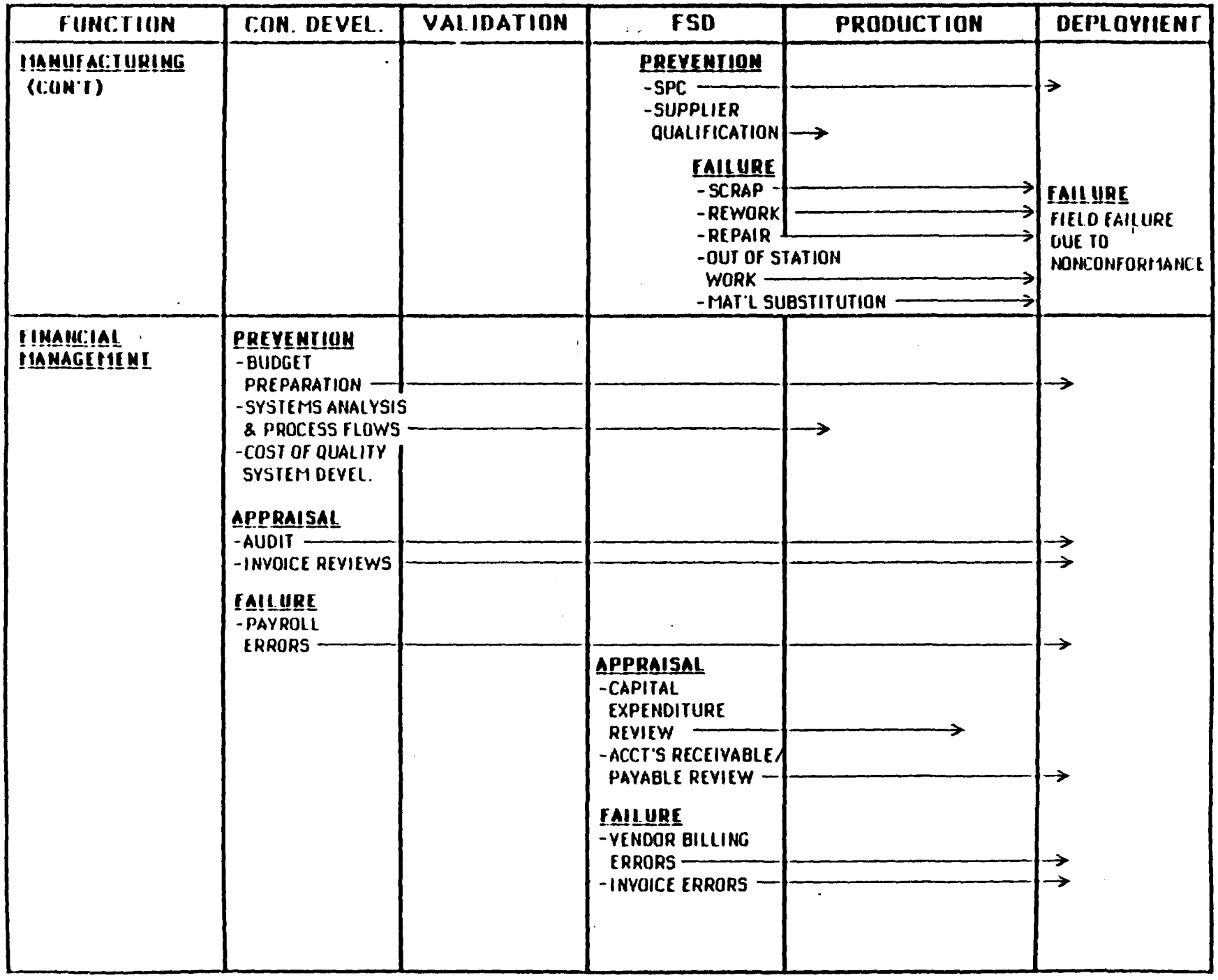
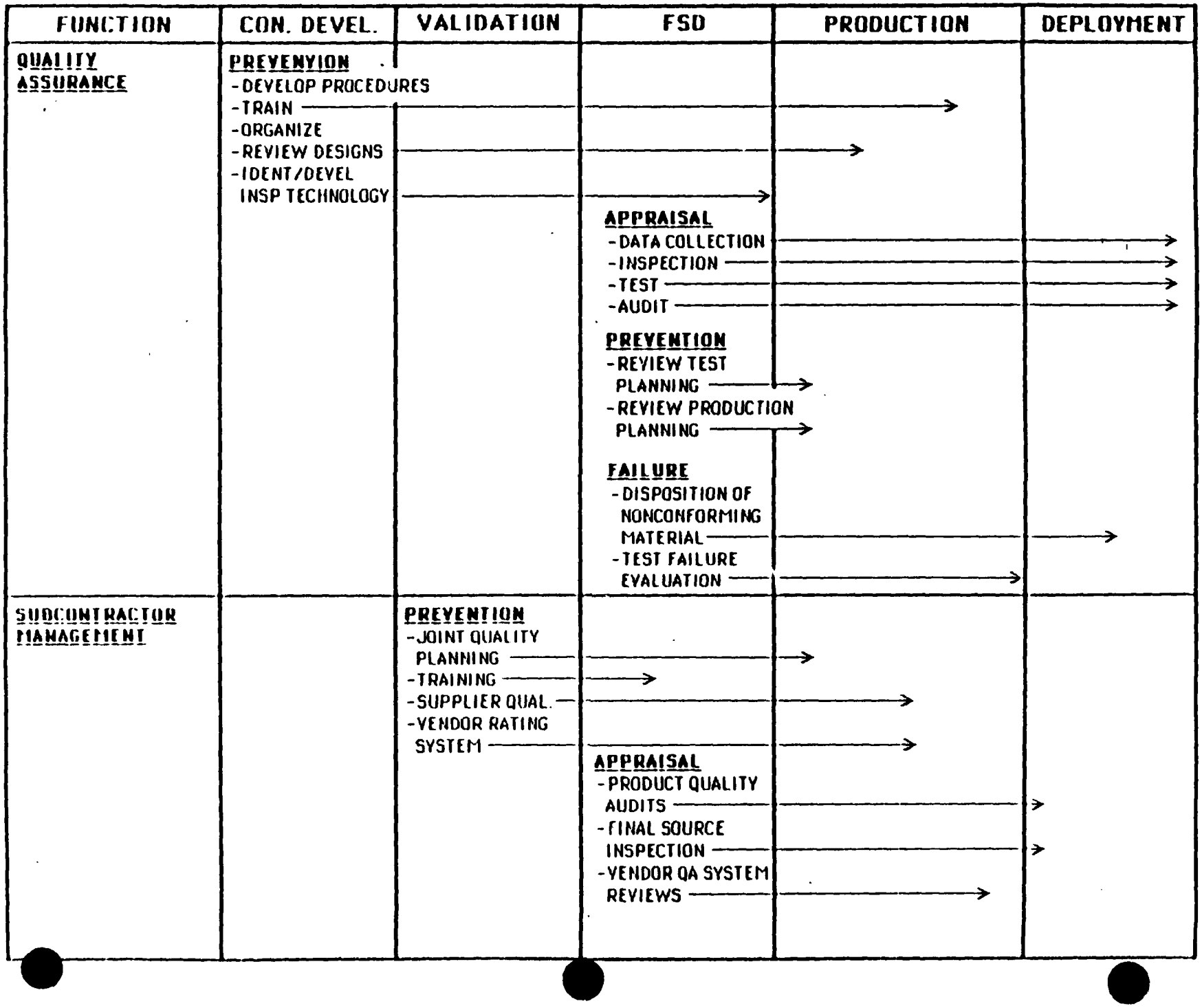

FUNCTION
CON. DEVEL.
VALIDATION
FSD
PRODUCTION
DEPLOYMENT
SYSTEMS ENGINEERING
(CON'T)
PREVENTION (HDWR&SFTWR)
-DEVELOP/USE STDS/HANDBOOKS
-CONFIGURATION CONTROL
INTERNAL FAILURE
DRAWING ERRORS
CODING ERRORS
FAILURE (INT/EXT)
FRACAS
EXTERNAL FAILURE
DRAWING ERRORS
CODING ERRORS
PREVENTION
SUPPLIER QUALIFICATION (HARDWARE & SOFTWARE)
APPRAISAL
SUPPLIER AUDIT
INTERNAL FAILURE
- DISPOSITION OF NON-CONFORMING MATERIAL
- ECNs
MANUFACTURING
PREVENTION
-PRODUCIBILITY
-TECH MOD
-MAN TECH
-PRODUCTION PLANNING
PREVENTION
-PLAN/EXECUTE RISK MANAGEMENT
APPRAISAL
-MM/PCR
APPRAISAL
-PRR
-WORK MEASUREMENT
-SUPPLIER AUDIT
-OPERATOR INSP

Table 3-1


FUNCTION
CON. DEVEL.
VALIDATION
FSD
PRODUCTION
DEPLOYMENT
MANUFACTURING (CON'T)
PREVENTION
-SPC
-SUPPLIER QUALIFICATION
FAILURE
-SCRAP
-REWORK
-REPAIR
-OUT OF STATION WORK
-MAT'L SUBSTITUTION
FAILURE
FIELD FAILURE DUE TO NONCONFORMANCE
FINANCIAL MANAGEMENT
PREVENTION
-BUDGET PREPARATION
-SYSTEMS ANALYSIS & PROCESS FLOWS
-COST OF QUALITY SYSTEM DEVEL.
APPRAISAL
-AUDIT
-INVOICE REVIEWS
FAILURE
-PAYROLL ERRORS
APPRAISAL
-CAPITAL EXPENDITURE REVIEW
-ACCT'S RECEIVABLE/ PAYABLE REVIEW
FAILURE
-VENDOR BILLING ERRORS
-INVOICE ERRORS


FUNCTION
CON. DEVEL.
VALIDATION
FSD
PRODUCTION
DEPLOYMENT
QUALITY ASSURANCE
PREVENTION
-DEVELOP PROCEDURES
-TRAIN
-ORGANIZE
-REVIEW DESIGNS
-IDENT/DEVEL INSP TECHNOLOGY
APPRAISAL
-DATA COLLECTION
-INSPECTION
-TEST
-AUDIT
PREVENTION
-REVIEW TEST PLANNING
-REVIEW PRODUCTION PLANNING
FAILURE
-DISPOSITION OF NONCONFORMING MATERIAL
-TEST FAILURE EVALUATION
SUBCONTRACTOR MANAGEMENT
PREVENTION
-JOINT QUALITY PLANNING
-TRAINING
-SUPPLIER QUAL.
-VENDOR RATING SYSTEM
APPRAISAL
-PRODUCT QUALITY AUDITS
-FINAL SOURCE INSPECTION
-VENDOR QA SYSTEM REVIEWS

FUNCTION	CON. DEVEL.	VALIDATION	FSD	PRODUCTION	DEPLOYMENT
SUBCONTRACTOR MANAGEMENT (CON'T)			**FAILURE** -REJECTED PARTS, ETC. → -SYSTEM AUDIT PROBLEMS → -LATE DELIVERIES →	→	→
LOGISTICS	**PREVENTION** -PLANNING FOR SUPPORTABILITY → -REVIEW OF LESSONS LEARNED →		→ **PREVENTION** -TRAINING LSA ANALYSTS -DEBUG/PROOF OF COMPUTER MODELS -DESIGNING FOR SUPPORTABILITY **APPRAISAL** -ILS PROGRESS REVIEWS → -LSA ANALYSES REVIEWS → -EQUIP. DESIGN REVIEWS →	→ → →	
			FAILURE -PLANNING ERRORS → -LSA ERRORS → -TECH ORDER ERRORS → -FACILITY DESIGN ERRORS →		→

FUNCTION	CON. DEVEL.	VALIDATION	FSD	PRODUCTION	DEPLOYMENT
CONTRACTS	**PREVENTION** -TRAINING → -DEVEL. HANDBOOKS, GUIDES, CHECKLISTS → -PROPOSAL/NEGOTIATION PLANNING → -COORDINATION OF NEGOTIATION STRATEGY → **APPRAISAL** -PRE-NEGOTIATION REVIEWS → -CONTRACT DOCUMENT REVIEW → -CHECK PROPOSAL AGAINST RFP → -REVIEW STATUS OF DELIVERABLES → **FAILURE** -PROPOSAL ERRORS → -NEGOTIATION ERRORS → -INVOICE/PROGRESS PAYMENT ERRORS → -LATE PROPOSALS → -DEFECTIVE PRICING →				

Table 3-1

COST ESTIMATING

There will be occasions when it is necessary for the Air Force evaluator to develop an estimate independently from the contractors estimate in order to allow for judgement about the validity of the contractor's numbers. There are a variety of techniques used in developing cost estimates, to include the use of:

- Estimating relationships
- Special Analogies
- Special Estimates
- Rates, factors, and catalog prices
- Industrial engineering standards
- Cost model applications
- Trend analysis
- Parametrics
- Bottoms up
- Historical costing

It is not the function or intent of this handbook to go beyond providing basic tools and approaches for estimating costs of quality.

The starting point for an evaluator must be a thorough understanding of what the tools are that are required by the contract.

Once the the tools are understood, both from the inherent nature of the work to be done, as well as from the specific and unique governmental requirements, the analyst can use the information provided in Chapter four to work up an estimate of the cost of quality. The technique outlined under "Analytical Techniques" for developing an empirical estimate is based on a detailed breakdown of the actual work content. Once the decision has been made on the extent to which the analyst must do independent estimating, the sources for data must be investigated. The following list (Figure 3-2) provides some typical sources of data:

Figure 3-2

Data Description	Data Source
Engineering drawings	Design data package
Product specifications	Design data package
Written description of product	Proposal
Bills of material	Manufacturing engineering, purchasing department
Organization chart	Personnel department
Ratios of labor, support,	Personnel department and engineering organization
Job descriptions and skill-level breakdown	Wage and salary administration
Collective bargaining contract	Labor relations department
Definition of direct/ indirect labor categories	DCAA audit, production management wage administration categories
Description of plant facilities	Proposal, process engineering
Special equipment and processes	
Management information system and ADP capability	ADP management
Manufacturing capability	DCAS capability study, prior contracts
Process sheets	Industrial and manufacturing engineering departments
Make-or-buy program	Proposal
Production schedules	Solicitation, proposal, production scheduling department
Purchase orders	Purchasing department
Material allowances	

Estimates Actual	Proposal, bill of material Production records of start quantity less shipped quantity
Proratables	Proposal support data
Cost-Estimating procedure	Proposal, cost estimating department
Production output records	Account, production control, management information system
Rework allowance	Proposal support data, inspection records, quality control department, production management
Schedule backlog	Production scheduling department, management information system
Labor efficiency report	Production management, industrial engineering department
Variance from standard performance	Cost accounting department, industrial engineering department
Breakdown of raw material dispersals	Inventory control department, material stores
Estimated spreadsheets	Proposal support data
Departmental estimates	Respective department management
Experience curve derivations	Cost estimating department, industrial engineering department
Cost estimating worksheets	Cost estimating department, industrial engineering department
Work measurement standards	Industrial engineering
Subcontractor quotes	Proposal, make-or-buy program, purchasing department
Historical costs: Estimated and actual spreadsheets	Contracting officer, direct cost analysis files

Direct cost factors	Prior contracts in contracting officer's files, contractor ADP files
Independent audits	DCAA, private consultants, NAVPRO, AFPRO, DCAS
Manufacturing engineering files	Process sheets Manufacturing process capabilities Engineering drawings Bills of material Tooling requirements
Design engineering files	Product specifications Reliability Quality Functionality Engineering drawings Special requirements Temperature Handling
Management information systems	Summary production reports Inventory Output Schedules Labor efficiency
Production control	Production schedules Production output records Material allowances and accounting procedures Bills of material for current jobs Material storage and dispersal procedures
Industrial engineering files	Development of cost estimating techniques Predetermined time values Standard data Worksheets Work sampling studies Experience curves Process sheets Historical labor performance data Job descriptions and skill breakdowns Description of plant facilities and capabilities

Cost estimating department	Cost estimating and accummulating procedure Departmental manpower requirements Product material estimates Experience curve applications Labor performance factors
Quality assurance files	Inspection plans and procedures Rework history Unusual product specifications
Purchasing department files	Current purchasing policy Purchase orders List of vendors Quotes from subcontractors
	Historical purchasing policy Make-or-buy program
Personnel Department	Relative labor mix, amount, and quality
	Ratios of various labor groups
	Organization characteristics
	Names of key personnel and contractor organization terminology
Production management Files	Labor performance reports
	Definitions of labor categories
	Direct/indirect Skilled/unskilled
Top Management	Explanation of questionable policies
	Authority for capital expenditures
	Knowledge for other data sources

Accounting department files	Cost breakdowns of labor category versus major product assembly
	Differentiation between direct and indirect costs
	Breakdown of overhead items
	Actual cost data (historical)

Factors that must be considered when making judgements about the nature of the contractors cost estimates must include:

- Past experience with similar/same product
- Make/buy situation
- State of contractors manufacturing capability (modern, labor intensive, etc.)
- Quantity to be produced
- Tolerance requirements
- Amount of development versus standard
- Product Complexity
- Contractors readiness (cold or warm base)
- Manufacturing technology required
- Inspection/test technology required

Always keep in mind the phase of the program, and recall that the level of effort required, and the nature of that effort, is directly driven by the phase the program is in, or will be in at the time for which costs are being estimated. (Note that DoD 4245.7-M, the "Transition Templates", is another excellent source of cost risk areas, broken down by program phase.) With all this in mind, the analyst can move on to the next step.

ANALYTICAL TECHNIQUES

Where the data needed to capture cost of quality is not readily available through the sources previously described, the particular analyst will have to perform some analytical action to develop an estimate of the cost. This is usually the case when dealing with indirect costs. This analysis can be done for a department, a section, a team, or for an individual. The technique differs only in the level of activity being reviewed, which will drive the values for the individual components that combine to develop the estimate. The process described below provides both an estimate of the total activity as well as an estimate of the cost of quality component of that activity. The technique is especially useful when dealing with level of effort kinds of activity, and in the indirect areas where the costs are generally pooled.

What follows is an instruction sheet that outlines the step by step technique. With that is an "Interview - Job Breakdown Worksheet" that is used to capture the data. A completed example worksheet is also provided to illustrate the actual application of the technique. Note that the example is for a "non traditional" quality measurement area, and should serve to reinforce the point that cost of quality is found in all functional areas.

INTERVIEW - JOB BREAKDOWN

STEP 1 — Discuss the major functional responsibilities of the job.

STEP 2 — List the major activities performed under each responsibility.

STEP 3 — Discuss the typical occurrence frequency of each major activity, usually weekly or monthly, quarterly, etc.

- look for objective evidence of that frequency

Ex.
- number of drawings
- number of reports
- number of tests
- number of items produced
- number of failures
- number of purchase orders

STEP 4 — Discuss the typical time required to perform each major activity. Sources for these times may be:

- established standards
- individual work logs
- actual observation, or a "walk through" of the activity involved

STEP 5 — Determine the period of performance for the proposed effort. Usually will be the period of the contract.

STEP 6 — Determine if the activity is a cost of quality. If yes, determine which category it represents.

STEP 7 — Calculate the hours required:

Frequency x Hours x Period of Performance = hrs. (for each major activity)

Add up all the individual hours to arrive at a subtotal

Using professional judgment, determine factor for (if applicable):

- supervision (%)
- miscellaneous tasks (%)

Then to subtotal	Subtotal Hrs
add Supervision factor x subtotal	Supervision Hrs
add Miscellaneous task factor x subtotal	Misc Hrs
Final Estimate _____	Hrs

INTERVIEW-JOB BREAKDOWN WORKSHEET

Functional Area____________________
Specific Job Title_____________________________
Period of Performance (weeks or months)___________

MAJOR ACTIVITY	TIME REQ'D	X FREQ =	EST	COQ? Y	COQ? N	PREV	APP	INT F	EXT F
SUB TOTAL →									
SUPERVISION FACTOR(__) X SUB TOTAL →									
MISC. TASK FACTOR(__) X SUB TOTAL →									
		TOTAL							

PROPOSED HOURS_________ **ANALYSIS HOURS**_________

COST OF QUALITY: PREVENTION________ **APRAISAL**________
INT. FAILURE________ **EXT. FAILURE**________

TOTAL COST OF QUALITY -

INTERVIEW-JOB BREAKDOWN WORKSHEET

Functional Area PURCHASING
Specific Job Title BUYER
Period of Performance (weeks or months) 18 MONTHS

MAJOR ACTIVITY	TIME REQ'D	X FREQ	= EST	COQ? Y	COQ? N	PREV	APP	INT F	EXT F
– REVIEW BILL OF MAT'L FOR MY TYPE OF PURCHASE	16 hrs	1	16 hrs		X				
– REVIEW CURRENT VENDOR LIST	4 hrs	30 P.O.s	120 hrs		X				
– PARTICIPATE IN VENDOR SURVEYS	24 hrs	5 Buys	120 hrs	X		X			
– OBTAIN QUALITY INP.T FOR PURCHASE ORDERS	2 hrs	30 P.Os	60 hrs	X		X			
– CORRECT PURCHASE ORDERS AFTER SUPERVISORY REVIEW	1 hr	2 P.Os.	2 hrs	X				X	
– ISSUE PURCHASE ORDERS	8 hrs	30 P.Os.	240 hrs		X				
FOLLOW UP WITH VENDORS TO ENSURE TIMELY DELIVERY	1 hr	90 (3 TIMES PER P.O.)	90 hrs	X			X		
– MAINTAIN VENDOR RATING RECORDS	2 hrs	30 P.Os.	60 hrs	X		X			
SUB TOTAL →			708						
SUPERVISION FACTOR(__) X SUB TOTAL →			N/A						
MISC. TASK FACTOR(10) X SUB TOTAL →			70						
		TOTAL	778						

PROPOSED HOURS 1225 ANALYSIS HOURS 778

COST OF QUALITY: PREVENTION 240 APRAISAL 90
INT. FAILURE 2 EXT. FAILURE –

TOTAL COST OF QUALITY - 332

Let's review briefly what has been presented in this chapter thus far:

- Sources for data reflecting cost of quality have been discussed.
- Various approaches to cost accounting that a contractor may use have been described.
- Cost estimating techniques for use by the Air Force analysts have been covered, to include another discussion of data sources.
- An analytical technique to be used when empirical cost data, of the detail needed by the analyst, is not available has been provided.
- Discussions and a checklist for use when making judgments about either proposed costs, or the analyst's own estimate, have been included.

All the above provide the tools necessary to now develop the cost of quality estimate for each functional area, and as a total for the contractor. Using the tools and techniques described, the analyst can follow the flow detailed in figure 3-3. The following is a narrative description of that flow.

Step 1. Review the contract. Ensure complete understanding of exactly what is required of the contractor. Special emphasis should be placed on cost of quality drivers. Refer to the "drivers" column in the tables provided under each function section of the handbook for help.

Step 2. Review the cost accounting approach used by the contractor. Gain an understanding of exactly how the contractor collects costs.

Step 3. Review existing data sources. Often the contractor will have a variety of reports, logs, etc., that can provide cost of quality figures. These figures may be usable numbers in their own right, or may provide a basis for making an estimate of some lower level figure.

Step 4. If sources do not exist such that the analyst can readily gain visibility into cost of quality, then the analytical technique "Interview - Job Breakdown" should be used to develop an estimate of the work content associated with cost of quality.

Note: In all likelihood, the answer to the question "sources

exist?", will be both yes and no. Sources will exist for some data, and not for others. The analyst will find it necessary to go down both branches, i.e., "yes" to "review costs proposed" and "no" to "apply analytical technique". Both branches lead back to step 5.

Step 5. Apply professional judgment to the costs/activities proposed. Ask, "Are the costs for the right effort?" In other words, is what the contractor is proposing to do in line with what he is required to do, or should do, as a normal course of action in that particular functional discipline? The checklist in appendix C, "Proposal Review Checklist", will be useful in accomplishing this step. If the answer is "yes", then ask, "Are costs of quality evident?". If the answer to either of these questions is "no", then go to step 6. If the answers to both is "yes", go to step 8.

Step 6. Verify contractual requirement. Be sure that a contractual basis exists for a given effort. Beyond that, good commercial practice, or accepted functional discipline approach can also be used as a judgment base for deciding the contractor has not proposed the correct effort. Once a requirement for the effort is established, go to step 7.

Step 7. Submit a request for clarification or additional information. Either the contractor neglected to include information in the proposal and can readily provide that information (in which case, go to step 8), or it will be necessary for the analyst to make an estimate of what the effort should be using the analytical technique under step 4.

Step 8. Capture cost of quality. Now judgments can be made about what is proposed, or has been estimated, in terms of what the government wants to achieve by having cost of quality data available for use as an effective management tool.

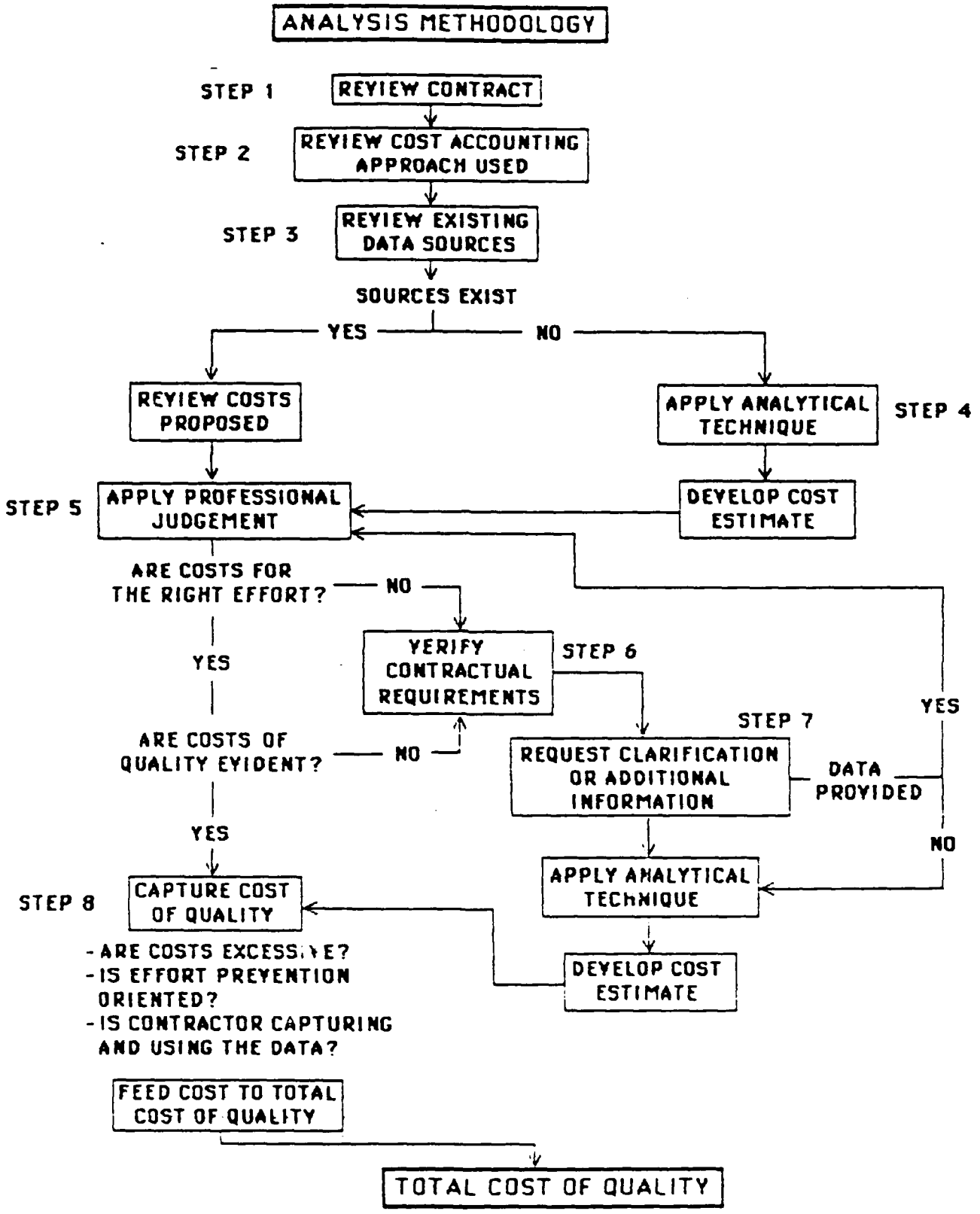

ANALYSIS METHODOLOGY
STEP 1
REVIEW CONTRACT
STEP 2
REVIEW COST ACCOUNTING APPROACH USED
STEP 3
REVIEW EXISTING DATA SOURCES
SOURCES EXIST
YES
NO
REVIEW COSTS PROPOSED
APPLY ANALYTICAL TECHNIQUE
STEP 4
STEP 5
APPLY PROFESSIONAL JUDGEMENT
DEVELOP COST ESTIMATE
ARE COSTS FOR THE RIGHT EFFORT?
NO
YES
VERIFY CONTRACTUAL REQUIREMENTS
STEP 6
STEP 7
ARE COSTS OF QUALITY EVIDENT?
NO
REQUEST CLARIFICATION OR ADDITIONAL INFORMATION
DATA PROVIDED
YES
NO
YES
APPLY ANALYTICAL TECHNIQUE
STEP 8
CAPTURE COST OF QUALITY
DEVELOP COST ESTIMATE
- ARE COSTS EXCESSIVE?
- IS EFFORT PREVENTION ORIENTED?
- IS CONTRACTOR CAPTURING AND USING THE DATA?
FEED COST TO TOTAL COST OF QUALITY
TOTAL COST OF QUALITY

Figure 3-3

HOW COST OF QUALITY IS SUMMARIZED

BY INDIVIDUAL PROGRAM

Basically, once the techniques described here, supported by the verification and audit activities outlined in Chapter five and the functional evaluations in Chapter four, have been completed, then a summary of cost of quality for a particular program can be put together. All direct costs that have been identified can be added under each functional area, by cost of quality category. For indirect costs, either the results of the analyst's estimate, or the contractor's allocation percentage for pooled hours can be used (if more than one program is supported in the contractor plant). Again, these estimates or allocations can be added up under each functional area, by cost of quality category. All these costs can then be totaled for the program, as shown in figure 3-4. Back up forms detailing each function may also be desired. These could take the form of the "Functional Area Worksheets" found at the end of each functional section in Chapter five.

FOR THE CONTRACTOR'S TOTAL COST OF QUALITY

The same approach as described above for a specific program applies for the total contractor cost of quality. In this case, all direct and indirect costs, by each functional area, that fall in each of the cost of quality categories is added up under each category to result in the total cost of quality for the contractor. The format in figure 3-4 applies for total company cost of quality also. Again, back up sheets by function may also be desired.

TOTAL COST OF QUALITY

FOR_____

FUNCTION	CATEGORY				
	PREVENTION	APPRAISAL	INT. FAILURE	EXT. FAILURE	TOTAL
PROGRAM MANAGEMENT					
ENGINEERING					
MANUFACTURING					
FINANCE					
QUALITY ASSURANCE					
SUB CONTRACT MGMT					
CONTRACTS					
TOTALS					

_____% _____% _____% _____%

AS OF DATE_____

DATE OF LAST REPORT_____

% CHANGES - _____ _____ _____ _____ _____

Figure 3-4

Survey Results

As part of the work done to develop this handbook, a telephone survey (copy in Appendix B) was conducted with 63 contractors representing the entire spectrum of products procured by all the buying divisions of Air Force Systems Command. In addition, visits were made to two contractors who have made significant use of the cost of quality as a management tool. One visit was made to a University to talk with a recognized expert in the field.

The results of all these survey activities are presented in Appendix B to give the handbook user some insight into what is the current thinking on cost of quality. The data is obviously only a sample population. As time toes on, the environment will change and most likely a similar survey could yield different results. The data is presented here as an aid in thinking about and planning for dealings with industry in the cost of quality area.

Functional Sections - Introduction

What follows are the detailed functional sections. Each is designed, when used in conjunction with the rest of the handbook, to enable the particular functional specialist to:

- identify the cost of quality in their area
- understand what drives the cost of quality
- focus on typical measures of the cost of quality
- make judgments about the costs
  - Are the costs correct (right activities)?
  - Are the costs reasonable (right amount;efficient)?
  - Is there evidence that the costs will produce the desired results (effective)?

A table has been constructed for each section which provides, as applicable:

- a list of major functional responsibilities
- a list of specific activities for each major responsibility
- a list of cost of quality efforts for each activity
- a list of conditions/requirements that tend to drive the cost of quality efforts
- typical measures of cost of quality effort

The purpose of the table is to enable the user to ask the right questions when evaluating a proposal in order to find the costs of quality. After this is accomplished, the evaluator can then use the worksheet provided to:

- determine those costs of quality that apply
- document the costs proposed for each effort
- document the analyst's allowed costs
- indicate the basis for judgment

Use of these aids, and the evaluation methodology techniques described in Chapter three, applied to the specifics in each functional area, will assist the evaluator in arriving at the desired results. The evaluator should rely on his or her experience and judgment when using these aides. They are not meant to provide all the answers, only to assist in the evaluation process. If the reader has not done a thorough job of studying the earlier sections of the handbook, or some time has past since initial study, a review is strongly recommended. Key areas are the definitions of the primary categories of appraisal, internal and external failure, and prevention. Proper application of the definitions given in Chapter one will be one of the most valuable steps in doing a cost of quality evaluation. The concept of cost of quality being present in all functional areas is also vital to proper understanding of where the costs can be found. Typical costs of quality that apply to all, or most, functional areas are:

- training
- work output review
- testing
- error accounting
- procedure development/use/maintenance
- planning

The analyst should focus attention on those cost of quality contributors that represent major costs. It is not possible, in view of limited government personnel resources and time available to analyze the given situation, to expect that every possible cost contributor can be found. The 80/20 rule - or the view that 80% of the cost will be found in 20% of the activities - is a good rule of thumb to follow. Again, the individual functional analyst's judgment must play a major role.

PROGRAM MANAGEMENT

The area of program management may appear on the surface to have little to contribute to the cost of quality. Remember, however, the term "output" used in Chapter one. Output refers to anything produced by any function in the organization, not only final product delivered to the ultimate customer. Program managers produce a vast array of outputs. Looking at the typical functions performed by program management, we find:

Organize

Plan

Build Team

Provide Leadership

Communicate

Control

React

Handle Customer Relations

In performing these functions, the typical program manager must be concerned with:

Contract Requirements

Program Plans

Risk Management

Contract Management

Configuration Management

Functional Management

Subcontractor Management

Product Performance

Accomplishing all of the functions outlined above allows the program manager to deal with the list of items he must be concerned with. Action to build the correct team, made up of the

right kinds and numbers of people, will ensure that the various functional activities will be provided for and accomplished. To a very great degree the upfront work done by the program manager to build the right team, formulate the right plan, and correctly implement and control all activity under that plan will determine how effective the organization is in executing the program.

Many of the activities performed by program managers are part of the total organization's cost of quality. Some examples are:

Prevention

- Team meetings to clearly explain contractual requirements
- Review of "lessons learned" from past programs
- Review of team member candidates to ensure proper qualifications and experience
- Training (administrative people; program management people)

Appraisal

- Program reviews
- Budget reviews
- Functional review support
  - Design reviews
  - Production readiness reviews
  - Configuration reviews

Internal Failure

- Typos/spelling, etc. during plan preparation
- Missed meetings
- Missed functional coverage in plans
- Missed coverage of contractual requirement
- Internal schedule slippage

External Failure

- Incomplete/inaccurate bids or proposals
- Erroneous program status reporting

- Late reports
- Missed reports
- Program schedule slippage

Program plans and schedules are good sources for identifying planned program and functional reviews. Records of bid and proposal activity can indicate where the customer received inadequate or erroneous information and had to ask for resubmission or clarification (External failure). Time spent by program management people preparing for and participating in various functional reviews can be determined from interviews and/or meeting minutes (Appraisal). Table 4-1-1 provides the breakout of responsibilities, actions, and cost of quality for program management. The worksheets which follow the table provide a method for the analyst to capture the cost of quality for a specific program.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
ORGANIZE	DECIDE ON PROGRAM OFFICE STRUCTURE			
	CONSIDER CONTRACTUAL REQUIREMENTS	PREVENTION - ENSURE NOTHING IS MISSED. ALL IS PROVIDED FOR IN PROPOSED STRUCTURE.		
PLAN	DEVELOP PROGRAM MANAGEMENT PLAN		DOD 5000 SERIES	
	REVIEW/UPDATE PLANS	APPRAISAL - ENSURE PLANS MEET REQUIREMENTS AND ARE CURRENT		
	PLAN FOR RISK MANAGEMENT	PREVENTION - ACTION TO IDENTIFY RISKS AND REDUCE/ ELIMINATE THEM	DODD 4245.7	- PERFORMANCE TO MILESTONES - PROVEN SUCCESS OF RISK REDUCTION/ ELIMINATION ACTIONS
	CONSIDER CONTRACTUAL REQUIREMENTS SEMP PMP PRODUCTION PLAN QA PLAN CONFIGURATION PLAN	(COVERED UNDER THE APPLICABLE FUNCTIONAL SECTION)		- PERFORMANCE TO SCHEDULE - CUSTOMER SATISFACTION BASED ON REVIEW

Table 4-1-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
BUILD PROGRAM TEAM	SELECT TEAM MEMBERS			
	TRAIN/ORIENT ON PROGRAM DETAILS	PREVENTION - ENSURE PEOPLE ARE AWARE OF AND ABLE TO MEET REQUIREMENTS		
	OBTAIN ADEQUATE FACILITIES			
	DEFINE RESPONSIBILITIES	PREVENTION - ENSURE PEOPLE ARE AWARE OF AND ABLE TO MEET REQUIREMENTS		
PROVIDE LEADERSHIP	(ACCOMPLISHED THROUGH ALL THE OTHER ACTIVITIES LISTED)			
ESTABLISH COMMUNICATION CAPABILITIES	SET UP TEAM MEETINGS	APPRAISAL - REVIEW PROGRESS, LOOK FOR ERRORS, PROBLEMS, ETC.		- SCHEDULE PERFORMANCE - COST PERFORMANCE - PERFORMANCE ACHIEVEMENT
	DESIGN UNIQUE MEMOS, REPORTS, ETC.			
CONTROL	PLAN PROGRAM REVIEWS		MIL-S-1521	
	CONDUCT PROGRAM REVIEWS	APPRAISAL - LOOK FOR PROBLEM AREAS FAILURE - ACTION TO CORRECT DEFICIENCIES	MIL-S-1521	- NUMBER OF PROBLEMS/ DEFICIENCIES - COST OF ACTIONS TAKEN TO CORRECT PROBLEMS VS. TOTAL COST OF THE REVIEWED EFFORT

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
REACT	FORM AD HOC GROUPS AS NEEDED	PREVENTION - REACTION TO AN ANTICIPATED PROBLEM	PROGRAM REVIEWS	
		FAILURE - ACTION TO FIX A PROBLEM	TEAM MEETINGS	
	VERIFY CORRECTION OF PROBLEMS	APPRAISAL - REVIEW TO ENSURE PROBLEM IS BEING/ HAS BEEN FIXED AND NO LONGER EXISTS		- CORRECTION SUCCESS RATE - PERFORMANCE TO SCHEDULES FOR SOLUTION IMPLEMENTATION
HANDLE CUSTOMER RELATIONS	PRESENT STATUS BRIEFINGS		AS REQUIRED	
	RESPOND TO SPECIAL REQUESTS		AS REQUIRED	

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - PROGRAM MANAGEMENT

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
PROGRAM REVIEWS							
BUDGET REVIEWS							
FUNCTION REVIEW SUPPORT							
DESIGN REVIEW							
PRODUCTION READINESS							
CONFIGURATION							
INTERNAL FAILURE							
ERRORS IN PLAN PREPARATION							
MISSED MEETINGS							
MISSED FUNCTIONAL COVERAGE IN PLANS							
MISSED COVERAGE OF CONTRACTUAL REQUIREMENT							
INTERNAL SCHEDULE SLIPPAGE							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - PROGRAM MANAGEMENT

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
EXTERNAL FAILURE							
INCOMPLETE/ INACCURATE BID OR PROPOSAL							
ERRONEOUS PROGRAM STATUS REPORTING							
LATE REPORTS							
MISSED REPORTS							
PREVENTION							
TEAM MEETING TO CLARIFY/EXPLAIN PROGRAM REQUIRE-MENTS							
REVIEW OF "LESSONS LEARNED"							
TRAINING							
SCREENING OF PROGRAM TEAM CANDIDATES							
TOTALS							

ENGINEERING

Engineering specialties are those disciplines which support the design process by applying knowledge from a specific area to ensure system operability in its intended environment. These disciplines include, for example:

reliability

producibility

maintainability

human engineering

transportability

safety

electromagnetic compatibility

parts/materials/processes

All these specialists are integrated into the Systems Engineering process. Once the customer's requirements have been clearly established, it is the engineering function's job to convert these requirements into a solution that meets those requirements.

Many of the specialist functions performed by engineering are in and of themselves directly related to the quality of the final product, under reliability engineering, test engineering, and liaison engineering.

Judgments about the acceptability and appropriateness of all planned engineering tasks and the man-hours proposed to perform those tasks will be made by the government evaluator(s) in the engineering function. As part of the evaluation of planned tasks, the evaluator(s) should look for the presence and absence of tasks normally associated with the cost of quality. Refer to the second and third columns of table 4-2-1 as a guide to identifying these tasks. Beyond the identification of the tasks, professional judgment concerning the resources (time, manpower, and equipment) proposed against each task is then applied. It is possible the evaluation will result in both increases as well as decreases being judged appropriate.

Table 4-2-1 provides a breakdown of the typical Systems Engineering functions and tasks one can expect a contractor to be performing. The applicability of some tasks may be dictated by the program phase. Others may be driven by contractual requirements imposed by the government, as shown in the fourth column. Typical measures of these costs of quality are provided in column five.

Examples of Cost of Quality in engineering

Appraisal (evaluate, measure, or audit output)

- Design reviews
- Drawing review
- Test audit
- Evaluate design for R M and Producibility
- Checking CAD, CAE, Drafting
- Vendor quality tracking

Failure (determine, disposition, rework, repair, scrap, correct defective output)

internal (before delivery)

- Drawing errors prior to release
- Design errors prior to release
- Redesign problem solving prior to release
- Debug CAD, CAE, Drafting programs
- Test equipment failure
- MRB support

external (after delivery)

- Drawing errors after release
- Design errors after release
- Redesign problems solving after release
- Liaison calls
- Customer acceptance test
- Field return evaluation/disposition
- Field service

prevention (avoid)

- Develop maintain/use of design handbooks
- Training
- Test planning and design
- Establish Quality Assurance Requirements
- Vendor qualification requirements
- Document/validate CAD, CAE, Drafting
- Test audit/set up
- Vendor surveys

Now look at table 4-2-1 for detailed breakout of major engineering responsibilities, specific actions, associated cost of quality, and method for capturing those costs.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
DEVELOP SYSTEMS DESIGN	DETERMINE DESIGN REQUIREMENTS	PREVENTION - ENSURE CUSTOMER REQUIREMENTS ARE CLEARLY UNDERSTOOD	MIL-S-499A	- PLANNED VS. ACTUAL DESIGN RELEASES - PLANNED STARTS VS. ACTUAL DESIGN STARTS - DESIGN ERRORS AS A % OF TOTAL DESIGN - DESIGN REWORK AS A % OF DIRECT DESIGN HOURS
	INVESTIGATE TECHNOLOGY INFORMATION BASE	PREVENTION - ENSURE PROPER, MATURE, AVAILABLE TECHNOLOGY IS USED, OR PLAN TO MANAGE NEW TECHNOLOGY		
	DEVELOP DETAILED DESIGN (HARDWARE AND COMPUTER SOFTWARE)	PREVENTION - TRAINING; HANDBOOKS APPRAISAL - DESIGN REVIEWS, DRAWING REVIEWS, CHECKING CADD, CAE INTERNAL FAILURE - DRAWING ERRORS, DESIGN ERRORS, DEBUG CADD, CAE EXTERNAL FAILURE - DRAWING ERRORS, DESIGN ERRORS, CODING ERRORS		- PARETO ANALYSIS OF DESIGN ERROR CAUSES
	DEVELOP/FABRICATE PROTOTYPE MODELS	PREVENTION - VERIFY DESIGN APPRAISAL - LOOK FOR PROBLEMS		- PERFORMANCE AGAINST MODEL DEVELOPMENT/ FABRICATION SCHEDULE

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		INTERNAL FAILURE - CORRECT DESIGN/ DRAWING PROBLEMS		
	FUNCTIONAL VERIFICATION	APPRAISAL -		
		PREVENTION -		
	ENGINEERING MODELS	PREVENTION - VERIFY DESIGN		(SAME AS PROTOTYPE)
		APPRAISAL - LOOK FOR DEFICIEN- CIES IN DESIGN/ DRAWING		
		INTERNAL FAILURE - DEVELOP CORRECTIVE ACTIONS BEFORE TRANSITION TO PRODUCTION		
	QUALIFICATION HARDWARE	INTERNAL FAILURE - DEVELOP CORRECTIVE ACTIONS BEFORE TRANSITION TO PRODUCTION		
	TRADE STUDIES	PREVENTION - ENSURE SELECTION OF MATERIALS AND PROCESSES THAT BOTH MEET CUSTOMER/DESIGN REQUIREMENTS AND EXISTING OR PLANNED PRODUCTION CAPABILITY	MIL-S-1528A	- REDESIGN HOURS CAUSED BY LACK OF OR POOR TRADE STUDY EFFORT FOR PRODUCIBILITY

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
DEVELOP SYSTEM SPECIFICATIONS	DEVELOPMENT OF STANDARDS (HARDWARE AND COMPUTER SOFTWARE)	PREVENTION - ESTABLISH AND STANDARDIZE DESIGN PROCESS	MIL-S-490	- SCHEDULE PERFORMANCE - WORK UNIT STARTS VS. PLANNED - REWORK HOURS AS A % OF TOTAL HOURS
	DEVELOPMENT OF HANDBOOKS (HARDWARE AND COMPUTER SOFTWARE)	PREVENTION - ESTABLISH AND STANDARDIZE DESIGN PROCESS		(SAME AS STANDARDS)
	GENERATION OF DRAWINGS	PREVENTION - TRAINING, DOCUMENT/ VALIDATE CADD, CAE APPRAISAL - DRAWING REVIEW INTERNAL FAILURE - DRAWING ERRORS BEFORE RELEASE EXTERNAL FAILURE - DRAWING ERRORS AFTER RELEASE	MIL-S-100	- ACTUAL PLANNING VS. PLANNED - ACTUAL VS. PLANNED STARTS - ACTUAL VS. PLANNED COMPLETES - ERRORS AS A % OF TOTAL RELEASES - DRAWING REWORK AS A % OF TOTAL DIRECT HOURS - PARETO OF ERRORS
	SYSTEM SPECIFICATION		MIL-S-961B	(SAME AS DRAWINGS)
	PERFORMANCE SPECIFICATION		MIL-S-490 MIL-S-83490	
	PRODUCT SPECIFICATION		DI-A-5026A	

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
SYSTEM EFFECTIVENESS	RELIABILITY ANALYSIS	PREVENTION - PREDICT SYSTEM PERFORMANCE AND DESIGN IN REQUIRED CAPABILITY	MIL-S-7858B	
	SAFETY AND HAZARDS ANALYSIS	PREVENTION - ENSURE DESIGN FEATURES THAT PREVENT POTENTIAL RISKS ARE ELIMINATED	MIL-S-882B	
	FMEA	PREVENTION - ANTICIPATE FAILURES AND DESIGN IN PROTECTION	MIL-S-470A	- TEST FAILURES DUE TO LACK OF/POOR FMEA - SCHEDULED EFFORT VS. ACTUAL
	EMC COMPLIANCE	PREVENTION - ENSURE ELECTRO MAGNETIC ASPECTS ARE CONSIDERED		
	DEFINE ACCEPTABLE PARTS, MATERIALS AND PROCESSES, AND SET UP CONTROL SYSTEMS	PREVENTION - ENSURE CONSISTENCY AND CONTROL OVER ITEMS CRITICAL TO SYSTEM SUCCESS	MIL-S-965A	
DEVELOP TEST REQUIREMENTS	INSPECTION TO DETERMINE CONFORMANCE WITH REQUIREMENTS DEMONSTRATION - AUDIT CONDUCT OF TEST	BASICALLY ALL COSTS ASSOCIATED WITH THE TEST FUNCTION ARE COSTS OF QUALITY	MIL-S-810D	

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
	ACTUAL TEST - AUDIT TEST SET UP	APPRAISAL - ALL TEST COSTS EXPENDED IN AN EFFORT TO JUDGE THE ACCEPTABILITY OF OUTPUT AND TO IDENTIFY ANY INSTANCE OF NON-CONFORMANCE		- TEST FAILURES CAUSED BY - UNCLEAR PROCEDURES - IMPROPER SET UP DUE TO PLANNING ERRORS - WRONG TEST PARAMETER
	ANALYSIS - FRACAS	FAILURE - ALL TEST COSTS ASSOCIATED WITH ACTIVITY REQUIRED TO EVALUATE AND EITHER CORRECT OR REPLACE OUTPUT THAT FAILS TO MEET ESTABLISHED QUALITY STANDARDS AND/OR PERFORMANCE REQUIREMENTS DURING TEST		
ESTABLISH PROCEDURES FOR INTEGRATION AND INTERFACE MANAGEMENT	PROGRAM CONTROL SUPPORT - SCHEDULES - COST PERFORMANCE DATA	PREVENTION - ENSURE ALL PLANNING IS CONSISTENT AND BASED ON COMMON, ACHIEVABLE TIME LINE	MIL-S-499A	- SCHEDULE PERFORMANCE
	- SCHEDULE PERFORMANCE	APPRAISAL - EVALUATE PERFORMANCE TO ESTABLISHED TIME LINE. DETERMINE CAUSE FOR VARIANCE.		

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
	SOFTWARE - DESIGNS - TEST PLANS/PROCEDURES - TEST RESULTS	(SEE UNDER DESIGN, TEST, AND CONFIGURATION)	DOD-S-2167 DOD-S-2168	- SCHEDULE PERFORMANCE - ACTUAL CODING STARTS VS. PLANNED - CODING ERROR RATES - GROWTH RATE - REPEATS
	DESIGN ENGINEERING - DESIGNS - TEST PLANS/PROCEDURES - TEST RESULTS	(SEE UNDER DESIGN, AND TEST)		
	TEST AND EVALUATION - INTEGRATION PLANS - INSTALLATION PLANS - SEGMENT TEST PROCEDURES - TEST RESULTS	(SEE UNDER TEST)	MIL-S-910D	- FRACAS REPORTS - TEST FAILURES - % OF TESTS FAILED
	SUBCONTRACT MANAGEMENT - VENDOR SURVEYS - DESIGNS - TEST PLANS/PROCEDURES - TEST RESULTS	PREVENTION - SELECTION OF QUALIFIED SUPPLIERS, CLEAR DEFINITION OF REQUIREMENTS FAILURE - (SEE APPRAISAL - UNDER TEST)	MIL-S-1535A	- VENDOR REJECT RATES - TEST FAILURES DUE VENDOR ITEMS AS % OF TOTAL TESTS - REWORK/REPAIR OF VENDOR PARTS AS A % OF - TOTAL REWORK/ REPAIR - TOTAL DIRECT HRS

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
	QUALITY ASSURANCE - FAILURE NOTICES	FAILURE - (SELF EXPLANATORY)	MIL-Q-9858A	(SEE ENTIRE QUALITY FUNCTIONAL AREA, 5-6)
	- DESIGN DISCREPANCIES NOTICES	APPRAISAL - IDENTIFICATION OF FAILURES AND CAUSES. NOTIFICATION OF DESIGN PROBLEMS THAT MAY LEAD TO PRODUCTION/ PERFORMANCE PROBLEMS		
	CONFIGURATION MANAGEMENT - TECHNICAL REQUESTS FOR CHANGE	PREVENTION - CONTROL OF DESIGN DOCUMENTATION TO ENSURE COMMON BASELINE	MIL-S-483 MIL-S-480A	(SEE CONFIGURATION BELOW)
		APPRAISAL - AUDIT OF COMPLIANCE OF "AS BUILT" PRODUCT TO THE CONTROLLED DESIGN BASELINE		
		FAILURE - DETERMINE CAUSES OF DEVIATIONS FROM ESTABLISHED CONFIGURATION		
ESTABLISH CHANGE CONTROL PROCEDURES	CONFIGURATION IDENTIFICATION	PREVENTION - ESTABLISH A STANDARD BASELINE FOR ALL OTHER FUNCTIONS TO WORK AGAINST	MIL-S-482	

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
	SUPPLIER CONTROL PURCHASING	FAILURE - DETERMINE DISPOSITION OF NON CONFORMING OUTPUT, AND ANALYSIS OF CAUSE TO PERMIT EFFECTIVE CORRECTIVE ACTION ALL COSTS UNDER ENGINEERING LIAISON ARE COSTS OF QUALITY		
PLAN ENGINEERING WORK	ALLOCATE MANPOWER DETERMINE/ALLOCATE SKILLS SCHEDULE WORK EFFORT	PREVENTION - ENSURE PROPER NUMBER OF APPROPRIATE SKILLS ARE AVAILABLE	MIL-S-499A	- PLANNED MANPOWER VS. ACTUAL - PLANNED DRAWINGS STARTS VS. ACTUAL
QUALITY ASSURANCE	SUPPLIER EVALUATION	PREVENTION - ENSURE SUPPLIER HAS CAPABILITY TO MEET DESIGN REQUIREMENTS BEFORE PRODUCTION START	MIL-Q-9858A MIL-S-1520C MIL-S-1535A	(SEE ENTIRE QUALITY FUNCTIONAL AREA UNDER 5-6)
	FIRST PIECE APPROVALS	APPRAISAL - CONFIRM PROCESS PRODUCES CONFORMING PARTS	DOD-S-2168	

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
	CONFIGURATION CONTROL (HARDWARE AND COMPUTER SOFTWARE)	PREVENTION - ENSURES CONSISTENT INFORMATION IS AVAILABLE TO ALL FUNCTIONS CONCERNING CHANGES TO THE STANDARD BASELINE	MIL-S-480A MIL-S-483	
	CONFIGURATION STATUS ACCOUNTING	PREVENTION - PROVIDE DOCUMENTED EVIDENCE OF THE EXISTING BASELINE, FOR USE AS THE STANDARD BY ALL OTHER FUNCTIONS	MIL-S-482	
	CONFIGURATION AUDITS	APPRAISAL - VERIFIES CONFORMANCE TO THE ESTABLISHED BASELINE	MIL-S-1521A	
ADVISE "FUNCTIONAL" SPECIALISTS	ENGINEERING LIAISON - QUALITY	PREVENTION - PROVIDE CLARIFICATION PRIOR TO ACTUAL START OF EFFORT TO AVOID ERRORS	MIL-S-1528A MIL-Q-9858A	(SEE PREVIOUS COMMENTS FOR EACH OF THESE FUNCTIONAL AREA)
	- MANUFACTURING	APPRAISAL - VERIFIES COMPLIANCE WITH ESTABLISHED DESIGN REQUIREMENTS, TEST PROCEDURES, ACCEPTANCE PLAN, ETC	MIL-S-1535A	
	- TEST		MIL-S-810D	

Table 4-2-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		PREVENTION - ENSURE PROCESS IS IN CONTROL PRIOR TO PRODUCTION RUN		
	MATERIAL REVIEW	FAILURE - EVALUATE AND RECOMMEND DISPOSITION OF NON CONFORMING PRODUCT		
	TEST AUDIT	PREVENTION - ENSURE TEST IS PROPERLY SET UP PRIOR TO TEST RUN		(SEE TEST ABOVE AND UNDER 5-6)
		APPRAISAL - EVALUATE RESULTS OF TEST TO CONFIRM REQUIREMENTS ARE BEING MET		
PRODUCIBILITY	TRADE STUDIES TO REDUCE PRODUCTION RISK	PREVENTION -	MIL-S-1528A DI-MS-80163 DI-MS-80162A	(SEE ENTIRE MFG. FUNCTIONAL AREA UNDER 5-3)
	ESTIMATES OF PRODUCTION CAPABILITY REQUIREMENTS	PREVENTION -		
	ESTABLISH PRODUCTION RISK REDUCTION PROGRAM	PREVENTION -		
	ENGINEERING CHANGES TO ACCOMMODATE PRODUCIBILITY	PREVENTION - IF DONE BEFORE DESIGN RELEASE		
		FAILURE - IF DONE AFTER DESIGN RELEASE		

Table 4-2-1

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - ENGINEERING

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
DESIGN REVIEWS							
DRAWING REVIEWS							
TEST SET UP REVIEW							
TEST AUDIT							
DESIGN EVALUATION FOR R & M							
VENDOR QUALITY TRACKING							
CHECKING CADD, CAE, AND DRAFTING							
PROCESS REVIEWS							
INTERNAL FAILURE							
DRAWING ERRORS BEFORE RELEASE							
DESIGN ERRORS BEFORE RELEASE							
REDESIGN PROBLEM SOLVING BEFORE RELEASE							
DEBUG CADD, CAE, DRAFTING PROGRAMS							
TEST EQUIPMENT FAILURE							
MRB SUPPORT							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - ENGINEERING

ACTIVITY	COVERED YES	COVERED NO	PROPOSED	ALLOWED	BASIS TRENDS	BASIS ACTUALS	BASIS JUDGE
EXTERNAL FAILURE							
DRAWING ERRORS AFTER RELEASE							
DESIGN ERRORS AFTER RELEASE							
REDESIGN PROBLEM SOLVING AFTER RELEASE							
LIAISON CALLS							
FIELD SERVICE							
WARRANTY RETURN EVALUATION/DISPOS.							
PREVENTION							
DEVELOP/USE MAINTAIN HANDBOOKS							
TRAINING							
TEST PLANNING AND DESIGN							
ESTABLISH QA REQUIREMENTS							
DOCUMENT/VALIDATE CADD, CAE							
TEST SET UP/AUDIT							
VENDOR SURVEYS							
TOTALS							

MANUFACTURING

The manufacturing function consists of people with a diverse number of disciplines and skills, who collectively utilize information and allocated resources to produce a product.

For example, the manufacturing function includes some of the following skills and disciplines:

Industrial Engineering

Facilities Engineering

Manufacturing Engineering

Manufacturing Planning

Tooling Engineering

Production/Configuration Control

Software Programmers - Automated Systems/Equipment

Material Management

Computer Aided Manufacturing

Plant/Equipment/Tooling - Maintenance

Standards/Documentation Records Management

Shop Management

Crib Management

Fabrication

Process Management

Assembly

Management Information Systems Management

Manufacturing Inspection/Test

Training

Producibility

Internal Audit Management

Safety

Each of these activities is integrated into the overall manufacturing process. All manufacturing activities must be considered for cost of quality when a company enters competition for a government contract.

When a company is awarded a contract, it is imperative that initial quality planning for the manufacturing requirements be conducted at the earliest practical time. Quality costs for manufacturing must be identified for each contractual phase (i.e., development, full scale development, low rate initial production). Tasks to be performed within each phase must show quality costs and persons responsible for those identified tasks must be held accountable through a quality cost measurement system. To accomplish the manufacturing quality cost objectives an intense internal coordination and training effort is necessary. Additionally, the company business planning function must authorize any increased scope as a result of refined understanding of requirements or additional investments/resources that may be necessary. The business planning function should be accountable for reducing overhead (burden) quality costs with manufacturing cooperation and specific commitments.

If mutual understanding of manufacturing quality cost baselines, criteria, methods and objectives are in effect from the very beginning of a program, the government and the contractor representatives for manufacturing can manage their responsibilities for quality costs with effective corrective actions to reduce total quality costs.

Every required task performed or not performed by manufacturing has resultant cost of quality. Contractual requirements and program phase determine what these tasks are and when they are to be accomplished.

Some of the more typical tasks or activities associated with manufacturing cost of quality are listed below under the categories of Prevention, Appraisal, Internal Failure, and External Failure.

Examples of Cost of Quality in Manufacturing

APPRAISAL (evaluate, measure, or audit output)

- Manufacturing Inspection/Test
- Corrective Action, Material Review, and Disposition
- Parts Control Board
- Statistical Process Controls
- Cost Performance Reports

- Production Readiness Review
- Manufacturing Performance Measurement

FAILURE (determine, disposition, rework, repair, scrap, correct defective output)

Internal (before delivery)

- Internal/Supplier Scrap - Rework - Repair
- Rebalance - LOB system
- Improper Instructions
- Out of Station Work
- Machine, Tooling, Equipment - Downtime
- Retraining

External (after delivery)

- Field Failures
- Modification Expense
- Field Testing/Repair/Expense
- Operating Manual Changes
- Failure Reporting - Corrective Action Systems
- Lost Future Business

Prevention (avoid)

- Manufacturing Engineering - Design Coordination/ Producibility Analysis
- Risk Identification/Avoidance
- Requirements Review
- Methods, Equipment, Processes Review - Industrial Engineering
- Production Planning
- Training

Table 4-3-1 provides a breakdown of typical manufacturing functions and tasks a contractor would be expected to perform. The applicability of tasks may be dictated by contractual requirements and/or program phase. Typical measures or failure modes of the quality effort are provided in column five. To evaluate planned tasks one should look for the presence or absence of manufacturing tasks normally associated with cost of quality. Refer to the examples in the second and third columns of table 4-3-1 to help identify these tasks.

Professional judgment concerning the resources (time, manpower, equipment, facilities) against each task must be applied. Discussions between government and contractor representatives will be needed to ensure mutual understanding. Evaluation resulting in either increases or decreases could be judged appropriate dependent upon circumstances. Quality costs must first be viewed in relationships to a task. Judgment must then include balancing cost of quality with other costs and ensuring that reduction of a direct cost does not result in an unplanned increase of indirect cost or increased cost to another function. Conversely, an increased manufacturing quality cost may result in unplanned decreased costs to another function or to decreased overhead costs. Manufacturing cost of quality must always be categorized to have functional meaning/application to manufacturing. How that feeds into cost centers and accounting conventions is yet another problem that must be resolved, (e.g., how to link the manufacturing data base to the financial data base).

Manufacturing plays a key role in ensuring that the product it produces conforms to the design consistently and correctly over the life of the product with low production and maintenance cost. Cost of quality management efforts can play a significant part in the successful accomplishment of that role.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
MANUFACTURING MANAGEMENT	MANAGEMENT AUDIT - ANNUAL VERIFY COMPLIANCE EACH REQUIREMENT OF	APPRAISAL	MIL-S-1528A	COST OF INADEQUATE PROCEDURES, INSTRUCTIONS, COST OF NON-COMPLIANCE
CONTROL OF SUPPLIERS	SUPPLIER REVIEWS, PROGRAMS PROCEDURES, DATA	APPRAISAL	MIL-S-1528A	REVIEW COSTS TRAVEL COSTS
	SUPPLIER ASSISTANCE	INTERNAL FAILURE	MIL-S-1528A	SUPPLIER DOESN'T UNDERSTAND REQUIREMENTS
MANUFACTURING ENGINEERING	DESIGN PROCESS INTEGRATION SYSTEMS ENGINEERING INTERFACE DESIGN DECISIONS TRACED TO M.E.	PREVENTION	MIL-S-1528A	DESIGN REVIEWS TRAVEL, RESEARCH
INDUSTRIAL ENGINEERING	FACILITY LAYOUT MAN/MACHINE CAPABILITY SET UP TIMES PROCESS YIELD WORK MEASUREMENT	PREVENTION PREVENTION/APPRAISAL PREVENTION/APPRAISAL PREVENTION/APPRAISAL PREVENTION/APPRAISAL INTERNAL FAILURE	MIL-S-1528A	- WORK FLOW, TRANSACTIONS - TIME TO ESTABLISH ADEQUATE INSTRUCTIONS - CONTROL CRITERIA - PRODUCTIVITY - TOO MANY TRANSACTIONS - TOO MUCH TRAVEL TIME - OUT OF STATION WORK - CHOKE POINTS - RETRAINING - LOW YIELD RATES - IMPROPER STANDARDS - INADEQUATE CONTROLS

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
				- ACCIDENTS - COSTS PER UNIT
PRODUCTION MANAGEMENT	CONTRACT REVIEW	PREVENTION	DOD 4245.6	- COST TO REVIEW - COST TO COORDINATE REQUIREMENTS - TRAINING AND IMPLEMENTATION COSTS
PRODUCTION RISKS	DEFINE/REDUCE PRODUCTION RISKS	PREVENTION	DOD 4245.6	- COST TO REDUCE RISK MAN TECH IMIP
PRODUCIBILITY		PREVENTION	DOD 4245.6	- COSTS FOR METHODS, PROCESS IMPROVEMENTS CONTROLS (SEE TABLE 4-2-1)
RESOURCE REQUIREMENTS	LONG LEAD PROCUREMENTS CRITICAL MATERIALS LABOR SKILLS SPECIAL TEST EQUIPMENT SPECIAL TOOLING	PREVENTION	DOD 4245.6	COSTS FOR: - SUPPLIER QUALIFICATIONS - SPECIAL PURCHASE ORDERS - TRAINING - MAKE/BUY DECISIONS - SECOND SOURCES - INVENTORY STORAGE - PLANNING - PREPARATION FOR REVIEWS - FEASIBILITY STUDIES - CAPABILITY STUDIES

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
MILESTONE REVIEWS	DEMONSTRATION/VALIDATION FSD PRODUCTION DEPLOYMENT	APPRAISAL/PREVENTION PREVENTION/APPRAISAL APPRAISAL/FAILURE EXTERNAL FAILURE	DOD 4245.6	COST FOR PRR OR REPEAT PRR COST FOR LATE SCHEDULE FIELD REPAIRS OR FIELD TESTS
PRODUCTION MANAGEMENT	PRACTICES/EQUIPMENT OPTIMUM EVALUATION OF CHARACTERISTICS CONTRACTOR RESPONSIBLE FOR ALL INSPECTION/ TEST REQUIRED BY CONTRACT CONTRACTOR TENDERS ONLY CONFORMING PRODUCT TO THE GOVERNMENT	INTERNAL FAILURE	FAR 46.105	- INADEQUATE INSTRUCTIONS - INADEQUATE TRAINING - POOR SUPERVISION - LACK DISCIPLINE - CRITERIA LACKING - TEST EQUIPMENT NOT CALIBRATED, NOT STATE OF ART - TEST PROGRAMS DO NOT EVALUATE KEY CHARACTERISTICS - RETEST RATES - RECORDS DO NOT SHOW RESULTS - TESTS TOO OFTEN - CORRECTIVE ACTION INADEQUATE - TEST EQUIPMENT NOT AVAILABLE, WRONG EQUIPMENT - SPECIAL TEST EQUIPMENT NOT IDENTIFIED - INCORRECT TOLERANCES - TEST DATA AND CORRECTIVE ACTIONS NOT TRACEABLE

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
				- TEST REQUIREMENTS NOT UPDATED WITH ECNs - SUPPLIERS NOT INFORMED OF CHANGED TEST CRITERIA

Table 4-3-1

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - MANUFACTURING

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
MANUFACTURING INSPECTION/TEST							
MATERIAL REVIEW BOARD							
PARTS CONTROL BOARD							
STATISTICAL PROCESS CONTROLS							
COST PERFORMANCE REPORTS							
PRODUCTION READINESS REVIEW							
WORK MEASUREMENT							
REVIEWS/AUDITS							
INFORMATION SYSTEMS							
MANUFACTURING STABILITY - LOB							
INTERNAL FAILURE							
INTERNAL/ SUPPLIER - SCRAP- REWORK - REPAIR							
REBALANCE - LOB SYSTEM							
IMPROPER INSTRUC- TIONS							
OUT OF STATION WORK							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - MANUFACTURING

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
MACHINE, TOOLING, EQUIPMENT - DOWNTIME							
RETRAINING							
MATERIAL SUBSTITUTION							
ENGINEERING CHANGES							
SET UP FOR REWORK - REPAIR							
WRONG CONFIGURATION							
EXTERNAL FAILURE							
FIELD FAILURES							
MODIFICATION EXPENSE							
FIELD TESTING, REPAIR, EXPENSE							
OPERATING MANUAL CHANGES							
FAILURE REPORTING - CORRECTIVE ACTION SYSTEMS							
LOST FUTURE BUSINESS							
SUPPLIER ASSISTANCE							
LABORATORY TESTING							
SHIPPING COSTS							
TRAVEL COSTS							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - MANUFACTURING

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
PREVENTION							
MANUFACTURING ENGINEERING - DESIGN COORDINATION/ ANALYSIS							
RISK IDENTIFICATION - AVOIDANCE							
REQUIREMENTS REVIEW							
METHODS, EQUIPMENT, PROCESSES REVIEW							
PRODUCTION PLANNING							
TRAINING							
INITIAL QUALITY PLANNING AND QIP							
WORK INSTRUCTIONS							
SAFETY REQUIREMENTS							
DETERMINATION - CRITERIA - CHARACTERISTICS							
TOTALS							

Finance

The financial and/or accounting departments represent the money side of business management. Typically, the people who work in this function are charged with many responsibilities which include, but are not limited to tracking, profit and loss, income, capital worth, cash flow, tax accounting, cost accounting and control, inventory control, accounts payable and receivable, asset conservation, many forms of budgets, and financial policy and forecasting. Accounting reports are financial explanations of what has happened in the conduct of the company's business. In the case of budgets and some other reports, a forecast of the operation and conduct of the business in the future is being generated.

As is the case with other groups within an organization, (e.g.,legal or computer operations), a language unique to finance is often used. The analyst should become as familiar with the terms and words used by the particular contractor as possible. The primary purpose in any review of the financial area is to insure that you fully understand what you examine or are told. You must not only determine what is explained by the numbers, but also be keenly aware of what can be concealed. It is always acceptable to request additional explanation if you do not fully understand the data or information presented.

Developing cost of quality in any functional area, especially a white collar area, will involve some amount of judgment on the part of the analyst. For example, in business today, considerable effort has been directed toward reducing direct costs by measuring and controlling the process that produces the product. Meanwhile, overhead costs have continued to increase. Today it is likely to have a condition where white collar cost of quality exceeds cost of quality of blue collar workers. The cost of Quality Functional Area Worksheet which follows Table 4-4-1 provides some guidance to the analyst within the financial area. Keep in mind, there will probably be other costs within each category that are specific to the company under review. The information will, in many cases, not be quantifiable in dollars or hours from actual data available. Judgments must be used based on observation, or the experience of the analyst. Use of the technique provided in Chapter 3 is recommended. Examples of cost of quality in Financial Management are:

Appraisal (evaluate, measure, or audit output)

- audits, financial
- time and attendance review

- accounts payable reviews
- accounts receivable reviews
- invoicing reviews
- capital expenditure reviews
- order entry and business backlog reviews
- ledger reviews

Failure (determine, disposition, rework, repair, correct defective output)

Internal (before delivery)

- invoicing errors
- invoicing delays
- uncollected receivables
- accounting errors corrected
- payable discounts not realized

External (after delivery)

- invoicing errors
- payroll errors
- accounts payable errors - vendor relations
- excess telephone expense
- premium expenses, freight and interest, raw material, prepayment

Prevention (avoid)

- education, internal training, and external job related training
- budget preparation
- new product cost and selling price planning
- systems analysis and flow chart preparation
- quality cost system development

The judgment required to develop an informed opinion and conclusion should take into account any quality costs that are not included in the hours or dollars that are proposed. Also details of planned tasks should be examined to determine if costs in excess of those required are proposed. Special attention should be paid to the costs of Quality associated with contractual requirements.

Table 4-4-1 and the worksheet following the table, should be used to facilitate the analyst's review. The evaluation that is developed will of necessity be the result primarily of the professional judgment, deduction and conclusions of the analyst. Use the methodology outlined in figure 3-3.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
DEVELOP ACCURATE AND EFFICIENT INVOICING SYSTEM	INVOICING REVIEWS	APPRAISAL - INSURE PROPER AND ACCURATE INVOICING	GENERAL BUSINESS PRACTICE AND CONTRACT REQUIRE-MENTS	- DAYS OF UNCOLLECTED RECEIVABLE DUE TO BILLING DELAYS - RATIO TO TOTAL INVOICING - NUMBER OF DEFECTIVE INVOICES TO TOTAL INVOICES
		PREVENTION - TRAINING EFFORTS TO INSURE PROMPT AND AND ACCURATE BILLING	GENERAL BUSINESS PRACTICE AND CONTRACT REQUIRE-MENTS	- DAYS OF UNCOLLECTED RECEIVABLE DUE TO BILLING DELAYS - RATIO TO TOTAL INVOICING - NUMBER OF DEFECTIVE INVOICES TO TOTAL INVOICES
		INTERNAL FAILURE - INVOICING ERRORS INVOICING DELAYS	GENERAL BUSINESS PRACTICE AND CONTRACT REQUIRE-MENTS	- DAYS OF UNCOLLECTED RECEIVABLE DUE TO BILLING DELAYS - RATIO TO TOTAL INVOICING - NUMBER OF DEFECTIVE INVOICES TO TOTAL INVOICES
		EXTERNAL FAILURE - ADDITIONAL CLIENT COMMUNICATION EXPENSE ADDITIONAL TRAVEL EXPENSE	GENERAL BUSINESS AND CONTRACT REQUIRE-MENTS	- DAYS OF UNCOLLECTED RECEIVABLE DUE TO BILLING DELAYS - RATIO TO TOTAL INVOICING - NUMBER OF DEFECTIVE INVOICES TO TOTAL INVOICES

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		SALES REPRESENTATIVE LABOR TO RESOLVE DISPUTE	GENERAL BUSINESS PRACTICE AND CONTRACT REQUIRE-MENTS	- DAYS OF UNCOLLECTED RECEIVABLE DUE TO BILLING DELAYS - RATIO IS TOTAL INVOICING - NUMBER OF DEFECTIVE INVOICES TO TOTAL INVOICES
		ADJUSTMENTS TO SATISFY CLIENTS	GENERAL BUSINESS AND CONTRACT REQUIRE-MENTS	- DAYS OF UNCOLLECTED RECEIVABLE DUE TO BILLING DELAYS - RATIO IS TOTAL INVOICING - NUMBER OF DEFECTIVE INVOICES TO TOTAL INVOICES
		RE-INVOICE COSTS	GENERAL BUSINESS PRACTICE AND CONTRACT REQUIRE-MENTS	- DAYS OF UNCOLLECTED RECEIVABLE DUE TO BILLING DELAYS - RATIO TO TOTAL INVOICING - NUMBER OF DEFECTIVE INVOICES TO TOTAL INVOICES
EXTERNAL FAILURE COST CONTROL AND ACCOUNTING	RETURNED GOODS (NON-CONFORMING PRODUCT OR SERVICE DELIVERED TO CLIENT)	EXTERNAL FAILURE - - MATERIAL NON-CONFORMANCE - LABOR - INACCURATE INSTRUCTIONS - COSTS OF RECEIPT OF MATERIAL	CONTRACT REQUIRE-MENTS AND/ OR SPECIFI-CATIONS MIL-Q-9858A	- DOLLARIZED COST - RATIO TO SALES - RATIO TO VALUE ADDED - PARETO OF NON-CONFORMANCE CAUSES

Table 4-4-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		- COSTS OF REPLACEMENT OF MATERIAL		
	ALLOWANCES	EXTERNAL FAILURE - COST OF CONCESSIONS TO SATISFY CLIENT	CONTRACT REQUIREMENTS AND/OR SPECIFICATIONS	- DOLLARIZED COST - RATIO TO SALES - RATIO TO VALUE ADDED - PARETO OF NON-CONFORMANCE CAUSES
	WARRANTY COSTS	EXTERNAL FAILURE - COSTS TO SERVICE NON-CONFORMING PRODUCT/SERVICE AFTER DELIVERY	CONTRACT REQUIREMENTS AND/OR SPECIFICATIONS	- DOLLARIZED COST - RATIO TO SALES - RATIO TO VALUE ADDED - PARETO OF NON-CONFORMANCE CAUSES
	CLIENT COMPLAINT ASSESSMENT AND SETTLEMENT	EXTERNAL FAILURE - COSTS ASSOCIATED WITH REVIEW AND ADJUSTMENT FOR NON-CONFORMING PRODUCTS DELIVERED TO THE CLIENT	SPECIFICATIONS AND CONTRACT REQUIREMENTS MIL-Q-9858A	- DOLLARIZED COSTS - RATIO TO SALES - RATIO TO VALUE ADDED - PARETO OF NON-CONFORMANCE CAUSES
DEVELOP AND MANAGE AN EFFICIENT AND EFFECTIVE RECEIVABLES AND PAYABLES SYSTEM	ACCOUNTS RECEIVABLE REVIEWS	PREVENTION - TRAINING AND CUSTOMER CONTACT	GENERAL BUSINESS PRACTICE	- % OF COLLECTIONS WITHIN TERMS - PAST DUE RECEIVABLES RATIO TO TOTAL SALES
		APPRAISAL - RECEIVABLE REVIEWS	GENERAL BUSINESS PRACTICE	- DAYS RECEIVABLES PAST DUE
		FAILURE - EXCESS TRAVEL AND TELEPHONE EXPENSE	GENERAL BUSINESS PRACTICE	- % OF COLLECTIONS WITHIN TERMS

Table 4-4-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		SALES REP. LABOR FOR COLLECTION EFFORTS		- PAST DUE RECEIVABLES RATIO TO TOTAL SALES
		REDUCED CASH FLOW		- DAYS RECEIVABLES PAST DUE
	ACCOUNTS PAYABLE REVIEW	PREVENTION - TRAINING, SUPPLIER CONTRACT AND COMMUNICATION	GENERAL BUSINESS PRACTICE	- % OF COLLECTIONS WITHIN TERMS - PAST DUE RECEIVABLES RATIO TO TOTAL SALES
		APPRAISAL - PAYABLE REVIEWS	GENERAL BUSINESS PRACTICE	- % OF COLLECTIONS WITHIN TERMS - PAST DUE RECEIVABLES RATIO TO TOTAL SALES - DAYS RECEIVABLES PAST DUE
		FAILURE - VENDOR RELATION DETERIORATION	GENERAL BUSINESS PRACTICE	- % OF COLLECTIONS WITHIN TERMS - PAST DUE RECEIVABLES RATIO TO TOTAL SALES
		COSTS TO RESOLVE DISPUTES		- DAYS RECEIVABLES PAST DUE
		DISCOUNTS NOT REALIZED		
LEDGER REVIEWS	TRIAL BALANCES	FAILURE - ACCOUNTING ACCURACY AND REWORK	GENERAL BUSINESS PRACTICE	- VARIANCES IN BALANCES
ORDER ENTRY SYSTEM PERFORMANCE	SYSTEM REVIEW	PREVENTION - INTERNAL TRAINING		-- % OF ORDERS PROCESSED TO TIME REQUIREMENTS

Table 4-4-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
BUDGET SYSTEM REVIEW AND CONTROL	BUDGET ANALYSIS	FAILURE - CUSTOMER DISSATISFACTION CASH FLOW REDUCTIONS FROM DELAYED ORDER ENTRY SCHEDULE CHANGES FOR MANUFACTURING DUE TO IMPROPER ORDER ENTRY REDUCED PROFIT MARGINS INCREASED COSTS		- ACTUAL PERFORMANCE TO BUDGET

Table 4-4-1

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - FINANCE

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
AUDITS, FINANCIAL							
TIME AND ATTENDANCE REVIEW							
ACCOUNTS PAYABLE REVIEWS							
ACCOUNTS RECEIVABLE REVIEWS							
INVOICING REVIEWS							
CAPITAL EXPENDITURE REVIEWS							
ORDER ENTRY AND BUSINESS BACKLOG REVIEWS							
LEDGER REVIEWS							
INTERNAL FAILURE							
INVOICING ERRORS							
INVOICING DELAYS							
UNCOLLECTED RECEIVABLES							
ACCOUNTING ERRORS CORRECTED							
PAYABLE DISCOUNTS NOT REALIZED							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - FINANCE

ACTIVITY	COVERED YES	COVERED NO	PROPOSED	ALLOWED	BASIS TRENDS	BASIS ACTUALS	BASIS JUDGE
EXTERNAL FAILURE							
INVOICING ERRORS							
PAYROLL ERRORS							
ACCOUNTS PAYABLE ERRORS - VENDOR RELATIONS							
EXCESS TELEPHONE EXPENSE							
PREMIUM EXPENSES, FREIGHT AND INTEREST, RAW MATERIAL, PREPAYMENT							
PREVENTION							
EDUCATION, INTERNAL TRAINING, AND EXTERNAL JOB RELATED TRAINING							
BUDGET PREPARATION							
NEW PRODUCT COST AND SELLING PRICE PLANNING							
SYSTEMS ANALYSIS AND FLOW CHART PREPARATION							
COST OF QUALITY SYSTEM DEVELOPMENT							
TOTALS							

QUALITY ASSURANCE

Quality Assurance entails all those functions required to establish procedures and integrate program plans for achieving and maintaining the required level of product quality, reliability, and compliance with all customer requirements. Generally speaking, a quality organization will consist of departments or divisions responsible for:

- Quality Administration
- Quality Engineering
- Quality Operations
- Supplier Quality
- Metrology/Laboratory Support

A given quality organization will usually reflect some group responsible for each of these functions, although some may be combined with others. From a cost of quality perspective, everything done under the quality assurance function is part of the cost of quality. Many of the activities are done in conjunction with other functions, particularly engineering and purchasing. All activities will fall in one of the four major cost of quality categories.

The first step for the analyst is to evaluate the overall proposed quality assurance organization and the functional activities that are covered. Table 4-5-1 can be used as an aid, for both a generic list of major responsibilities and specific activities, as well as identifying drivers from a contractual requirements point of view. Questions to ask are:

- Are there any functions not covered by the proposed system?
- Are there any functions proposed that are not needed?
- Are all contractual requirements covered?
- Is there current evidence, resulting from Contract Administration Service surveillance, of either strengths or weaknesses in the existing/proposed system?

The second step is to look at the hours proposed for each function. Often the contractor will project certain functional hours as a percent of some other hour base, such as direct labor hours. Here are some typical basis for proposed hours.

Functional Hours		Basis for Proposal
Inspection	-	% of direct labor
	-	direct inspector hours
Test	-	planned test hours
Quality Engineering	-	% of direct labor
	-	% of direct inspection labor
	-	ratio, QAEs to operators
Vendor Quality	-	projected lots shipped
	-	number of suppliers

Many of these functions became level of effort activities and it is difficult to judge what their level should be. Using the "Interview - Job Breakdown" technique described in Chapter three, the evaluator can arrive at a estimate of the actual hours required.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
QUALITY POLICY	OPERATING PROCEDURE DEVELOPMENT	PREVENTION - DOCUMENTED METHODS AND PROCEDURES TO ENSURE EVERYONE UNDERSTANDS WHAT TO DO AND HOW TO DO IT	MIL-Q-9858A	- INSTANCES OF NON-COMPLIANCE WITH ESTABLISHED PROCEDURES - ERRORS IN PROCEDURES - PLANNED REVIEW/ UPDATE
QUALITY IMPROVEMENT PROGRAM	IMPROVEMENT PLAN	PREVENTION - ELIMINATE TRUE CAUSES BEFORE THEY LEAD TO PROBLEMS	MIL-S-1520C	- REPEATS OF PROBLEMS ADDRESSED BY QIP FIX - NON REOCCURRENCE OF PROBLEMS ADDRESSED BY QIP FIX - REPEATS PLOTTED AGAINST TOTAL QIP FIXES
	IMPROVEMENT PROJECTS	APPRAISAL - ANALYSIS OF PROBLEMS TO FIND CAUSES AND IMPLEMENT LASTING CORRECTIVE ACTION		
	TRAINING			
QUALITY FUNCTION & ORGANIZATION	DEFINE FUNCTIONAL RESPONSIBILITIES	PREVENTION - PROVIDE FOR ALL REQUIRED SUPPORT, TO ENTIRE ORGANIZATION	MIL-Q-9858A	- OCCURANCES OF UNCLEAR/IMPROPER FUNCTIONAL INTERFACE - LACK OF INDEPENDENCE FROM OPERATIONS
	CREATE ORGANIZATIONAL STRUCTURE TO MEET REQUIREMENTS			
QUALITY PROGRAM PLANS	ADOPT POLICIES/ PROCEDURES TO SPECIFIC PROGRAM REQUIREMENTS	PREVENTION - ENSURE ALL REQUIREMENTS ARE CLEARLY UNDERSTOOD AND COVERED	DI-R-5297A/M	

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
QUALITY STATUS REPORTING	CAPTURE DATA ON QUALITY FUNCTION RESULTS	APPRAISAL - EVALUATE THE PRODUCT'S QUALITY	MIL-Q-9858A	- DEFECT RATES - REPEAT DEFECT RATES - TEST FAILURES - REPEAT TEST FAILURES - SUPPLIER REJECTS - REPEAT SUPPLIER REJECTS - SCRAP - REWORK - REPAIR - USE AS IS
	GENERATE REPORTS	FAILURE - EVALUATE PROBLEMS AND PROPOSE/INITIATE FIXES PREVENTION - USE DATA TO IMPLEMENT PERMANENT FIXES		
QUALITY SYSTEM PERFORMANCE RATING	CONDUCT AUDIT AND REPORT RESULTS	APPRAISAL - ENSURE QUALITY SYSTEM IS DOING THE JOB	MIL-Q-9858A	- DISCREPANCIES PER AUDIT - DISCREPANCIES VS. TOTAL ELEMENT AUDITED - REPEAT DISCREPANCIES BY AREA
EVALUATE R & M QA REQUIREMENTS	REVIEW DESIGN	PREVENTION - ENSURE REQUIREMENTS ARE COVERED	MIL-Q-9858A	
	REVIEW TEST PLANS/ SET UP	PREVENTION - ENSURE TEST WILL BE CONDUCTED PROPERLY		
	AUDIT TEST	APPRAISAL - ENSURE TEST RESULTS ARE ACHIEVED AND EVALUATED		

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
APPLY STATISTICAL METHODS	CONDUCT PROCESS CAPABILITY REVIEWS	APPRAISAL - DETERMINE ABILITY OF PROCESS TO MEET SPECIFICATION REQUIREMENTS	MIL-S-1520C	
	APPLY SPC AS APPROPRIATE	PREVENTION - ENABLE PROCESS ADJUSTMENTS BEFORE DEFECTS ARE GENERATED		
	COLLECT/ANALYZE DATA	APPRAISAL - MONITOR ACTUAL PROCESS PERFORMANCE AND CAPTURE INSTANCES OF DEFECTIVE OUTPUT		
CORRECTIVE ACTION AND FOLLOW UP VERIFICATION	EVALUATE FAILURES	FAILURE -	MIL-Q-9858	- DEFECTS - REPEAT DEFECTS
	PROPOSE CORRECTIVE ACTION	APPRAISAL -	MIL-S-1520C	- TEST FAILURES - REPEAT TEST FAILURES
	IMPLEMENT CORRECTIVE ACTION			- REWORK - REPAIR
	VERIFY CORRECTIVE ACTION EFFECTIVENESS			
INSPECTION AND TEST PLANNING	PLAN FOR REQUIRED INSPECTIONS AND TESTS	PREVENTION - ENSURE QUALITY STATUS IS VERIFIED AT APPROPRIATE POINTS, IN THE APPROPRIATE MANNER	MIL-Q-9858A	- MISSED INSPECTIONS - MISSED TESTS - WRONG INSPECTIONS - WRONG TEST CONDUCTED

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
CALIBRATION OF TOOLS/ EQUIPMENT	ESTABLISH RECALL SYSTEM	PREVENTION - ENSURE EQUIPMENT IS KEPT IN SERVICABLE CONDITION SO THAT IT IS RELIABLE, ACCURATE, AND REPEATABLE	MIL-S-45662	- OVERDUE CALIBRATIONS - REINSPECTION DUE TO OVERDUE CALIBRATION
	MAINTAIN STANDARDS			
	PERFORM CALIBRATION			
DISPOSITION OF NON-CONFORMING MATERIAL (MRB)	PRE-REVIEW	FAILURE - DETERMINING DISPOSITION	MIL-S-1520C	- REPEAT DEFECTS - TOTAL MRB ACTIONS (TREND)
	REVIEW STANDARD REPAIR			
	LIAISON WITH ENGINEERING			
FIELD RETURNS	DETERMINE WARRANTY APPLICABILITY	APPRAISAL FAILURE		- FIELD RETURN RATE - REPEAT FIELD FAILURES
	CAPTURE FAILURE DATA			
QUALITY REVIEW OF DESIGN	ENSURE INSPECTABILITY	PREVENTION	MIL-Q-9858A	- DRAWING ERRORS ON QUALITY REQUIRE-MENTS
	SPONSOR DESIGN CHANGES FOR QUALITY			
COST OF QUALITY PROGRAM	COLLECT AND PRESENT DATA	APPRAISAL	MIL-Q-9858A	
	TAKE ACTION TO ADDRESS PROBLEM	FAILURE		
	ANTICIPATE PROBLEMS	PREVENTION		

Table 4-5-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
TEST OPERATION & AUDIT	RUN TESTS	APPRAISAL	MIL-Q-9858A	(SEE TEST UNDER ENGINEERING)
	ANALYZE TEST RESULTS	APPRAISAL		
	LIAISON WITH OTHER FUNCTIONS	FAILURE		
HANDLING STORAGE/DELIVERY			MIL-S-1367	
VENDOR QUALITY CONTROL	CONDUCT VENDOR SURVEYS	PREVENTION	MIL-S-1535A MIL-Q-9858A	
	MONITOR VENDOR PERFORMANCE IN THE FIELD	APPRAISAL		
	WORK SUPPLIER CORRECTIVE ACTION	FAILURE		
QUALITY LABORATORY SERVICES				

Table 4-5-1

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - QUALITY ASSURANCE

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
INSPECTION							
TEST							
MONITOR TESTS							
SYSTEMS AUDIT							
DATA ANALYSIS							
VENDOR AUDITS							
DESIGN REVIEWS							
INTERNAL FAILURE							
CORRECTIVE ACTION							
MATERIAL REVIEW							
SCRAP							
REWORK							
REPAIR							
EXTERNAL FAILURE							
CORRECTIVE ACTION							
VENDOR VISITS TO RESOLVE PROBLEMS							
VENDOR REJECTS							
DETERMINE WARRANTY COVERAGE							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - QUALITY ASSURANCE

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
PREVENTION							
QUALITY IMPROVEMENT PROJECTS							
METROLOGY							
TRAINING							
SUPPLIER QUALIFICATION							
TEST PROOF OUT							
QUALITY PLANNING							
QUALITY ENGINEERING							
TOTALS							

Subcontractor Management

The supplier of products, materials, and services, as well as non-product services, can be defined as the source from which the producer obtains many of goods and services required to operate the company. The terms supplier, vendor, seller, furnisher, dealer, wholesaler, retailer, distributor, and importer, among others, are used, interchangeably in many areas, to describe the source of materials and services. Usually government contractors use the terms vendor, suppliers, or subcontractor. In the case of standard materials and services, those which are common and have established standards, incoming inspection is typically appropriate for the certification and assurance of conformance. This is also generally applicable to minor components normally built to industry standards, but which may have specifications from the buyer or vendor. The requirements differ, however, where major products or services are concerned.

When major procurements are made, a different and more involved relationship is required between the prime contractor and the subcontractor. The materials in question are typically sophisticated and the time frame for delivery and use precludes the possibility of establishing a specification and providing incoming inspection at the proscibed delivery date to insure conformance. The buyer must establish a closer relationship with the supplier to insure that all aspects of the procurement are as closely managed, almost as if the product or service were actually made or produced at the prime contractors' facility utilizing employees of the prime contractor.

According to J.M. Juran, the establishment of the relationship for major purchases may consist of as many as 10 particular efforts. They are:

1. Establish a vendor Relations Q-policy.
2. Use multiple vendors for major procurements.
3. Establish a formal vendor qualification process.
4. Conduct joint quality planning; agree on responsibilities.
5. Establish two-way communication.
6. Set up to detect and remedy deviations.
7. Conduct vendor surveillance.

8. Exchange inspection data; provide certification.

9. Under take improvement programs set up material assistance.

10. Create and use vendor quality ratings.

Not all of these efforts will be necessary in every purchase, but this listing can serve as a checklist. Judgement will be required to determine which of these requirements should or should not be met and the cost associated with the function. The successful application of these efforts toward excellence in the product or service delivered represent the subcontract quality responsibility and the costs associated will be the subcontract cost of Quality. A major driver is usually MIL-STD-1535A. Examples of cost of quality in Subcontractor Management are:

Appraisal (evaluate, measure, an audit output)

- product quality audits
- in process and test inspection reviews
- manufacturing instruction reviews
- final source inspections
- vendor rating system
- combined MRB activities
- production readiness reviews

Failure

Internal (before delivery)

- redesign
- engineering change requirements
- additional equipment requirements
- purchase contract amendments
- excess travel and communication expense

External (after delivery)

- scrap
- rework
- returned goods replacement costs
- reinspection
- retesting
- increased transportation expense

Prevention (avoid)

- joint quality planning
- supplier quality systems reviews
- production risk assessments
- quality requirements for vendor contract
- personnel training
- packaging reviews

Judgement is essential in the evaluation of the subcontract function. It will seldom be possible to find easily all costs associated with the vendor relations and subcontract management responsibilites. Following Table 4-6-1 is a cost of quality functional Area Worksheet which will provide some examples of activities that might pertain to your evaluation of the function. These do not include all areas for evaluation. Each review will have costs specific to the business and operation involved. An effort must be made to indentify each and apply hours or dollarized costs as required. In some areas where hard, detailed costs have not been accumulated, or are part of aggregate costs for some other purpose, it will be necessary to estimate, observe or calculate to determine the cost of quality in question. When interviews and observations are required for making judgements the Job Breakdown Worksheet (described in Chapter three) can be helpful. In developing appropriate quality costs, it is important to evaluate the activities individually and determine that all activities are included and have not been overlooked or discounted and that all costs presented are in fact applicable. Also, be sure all contractual requirements have been included.

Considerable effort and expense has successfully been expended on controlling quality in the "manufacturing" cycle. Recent experience indicates that an equal or larger amount of contrcllable quality costs are lodged with the "white collar" functions. In fact, quality costs incurred by those who use pencils and telephones are as significant as those incurred by machine operators and manufacturing personnel. Less effort and resource have been applied to recognizing and capturing the cost of quality in the white collar functions, but it is clear that process control for business processes, such as vendor review programs or delivery schedule reviews in the subcontract management function, can be successfully applied.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
IMPLEMENTATION AND CONTROL OF VENDOR RATING SYSTEM AND VENDOR EVALUATION	VENDOR REVIEW	PREVENTION - TRAVEL AND VISIT COSTS AT VENDOR FACILITY. TRAINING	MIL-Q-9858A MIL-S-1520B	- DOLLARIZED COSTS % OF DEFECTIVE PRODUCTS DELIVERED
SOURCE INSPECTION AND CONTROL PROGRAM	VENDOR REVIEW	FAILURE - REWORK OF SUPPLIER MATERIAL	MIL-Q-9858A MIL-S-1520B AND GENERAL BUSINESS PRACTICE	- DOLLARIZED COSTS % OF DEFECTIVE PRODUCTS DELIVERED
		SCRAP OF SUPPLIER MATERIAL		- DOLLARIZED COSTS % OF DEFECTIVE PRODUCTS DELIVERED
PRODUCTION READINESS REVIEWS	VENDOR REVIEW	PREVENTION - DESIGN PRODUCIBLE/PROCESSES READY	MIL-S-1528A	- NECESSARY YIELDS DEMONSTRATED
		PURCHASED MATERIAL REJECTION PROCESS PROCESS AND MRB COSTS		- DOLLARIZED COSTS % OF DEFECTIVE PRODUCTS DELIVERED
		APPRAISAL - PRODUCT QUALITY AUDITS		
INSTITUTE AND MANAGE A JOINT QUALITY PLANNING PROGRAM	VENDOR REVIEW	PREVENTION - JOINT PLANNING AND TRAINING	MIL-Q-9858A MIL-S-1520B AND GENERAL BUSINESS PRACTICE	- DOLLARIZED COSTS % OF DEFECTIVE PRODUCTS DELIVERED
		TRAVEL AND COMMUNICATION COSTS		
		FAILURE - VENDOR SCRAP, REWORK, AND REPAIR	MIL-Q-9858A MIL-S-1520B AND GENERAL BUSINESS PRACTICE	- DOLLARIZED COSTS % OF DEFECTIVE PRODUCTS DELIVERED - PARETO REVIEW OF DEFECTS
		LABOR COSTS AND MATERIAL COSTS TO REPLACE DEFECTS		

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		PRODUCTIVITY LOSSES DUE TO MANUFACTURING RESCHEDULES TO REPLACE DEFECTS COSTS OF MAINTAINING ADDITIONAL INVENTORY ADDITIONAL MATERIAL COSTS TO REPLACE DEFECTS ADDITIONAL HANDLING AND TRANSPORTATION COSTS APPRAISAL - COLLECTION OF ALL QUALITY COSTS ASSOCIATED WITH DATA, DEFECTS, AND TRENDS		
STANDARD CONTRACT SPECIFICATIONS	VENDOR REVIEW OF PURCHASE DOCUMENTS	FAILURE - REDESIGN COSTS ENGINEERING CHANGE COSTS PREVENTION - SPECIFICATION REVIEWS WITH VENDOR ACCEPTANCE CRITERIA AGREEMENTS	MIL-S-1535A MIL-Q-9858A STANDARD BUSINESS PRACTICE	- DOLLARIZED COSTS - RATIO OF COSTS TO SALES - PARETO REVIEW OF ALL NON-CONFORMANCE

Table 4-6-1

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - SUBCONTRACT MANAGEMENT

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
PRODUCT QUALITY AUDITS							
IN PROCESS AND TEST INSPECTION REVIEWS							
MANUFACTURING INSTRUCTION REVIEWS							
FINAL SOURCE INSPECTIONS							
VENDOR RATING SYSTEM							
COMBINED MRB ACTIVITIES							
INTERNAL FAILURE							
REDESIGN							
ENGINEERING CHANGE REQUIREMENTS							
ADDITIONAL EQUIPMENT REQUIREMENTS							
PURCHASE CONTRACT AMENDMENTS							
EXCESS TRAVEL AND COMMUNICATION EXPENSE							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - SUBCONTRACT MANAGEMENT

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
EXTERNAL FAILURE							
SCRAP							
REWORK							
RETURNED GOODS REPLACEMENT COSTS							
REINSPECTION							
RETESTING							
INCREASED TRANSPORTATION EXPENSE							
PREVENTION							
JOINT QUALITY PLANNING							
SUPPLIER QUALITY SYSTEMS REVIEWS							
QUALITY REQUIREMENTS FOR VENDOR CONTRACT							
PERSONNEL TRAINING							
PACKAGING REVIEWS							
TOTALS							

LOGISTICS

Logistics is an integral part of the acquisition of any new weapon system. The system's support must be integrated into the development process, so the term Integrated Logistics Support (ILS) refers to the management and analysis actions necessary to assure effective and economical support of a material system, both during the various phases of development through deployment and disposition.

Specific areas must be considered in accomplishing the ILS process. DoD Direct 5000.39 defines nine (9) elements of ILS as follows:

Maintenance Plan

Manpower and Personnel

Supply Support

Support and Test Equipment

Training and Training Devices

Technical Data

Computer Resource Support

Packaging, Handling, Storage, and Transportation

Facilities

The contractor will normally be tasked with the requirement to perform Logistics Support Analysis (LSA) as the formal process of examining the weapon system and ensuring that all the logistics support elements are considered. Government decisions regarding the maintenance concept are critical to determining the nature of a majority of the other elements. The maintenance plan tends to drive all the other elements.

The government's ILS plan will provide specific task oriented guidance to the contractor regarding what must be done to plan for and adequately cover the nine ILS elements. Typical activities are:

Maintenance Concept Analysis

Lessons Learned Review

Develop Maintenance Allocation Chart

Technology Assessment

Built in Test

Automated Test Equipment

System Diagnostics

Organic versus Commercial Support

Deployment Analysis

Facilities Requirements Analysis

Training Analysis

The nature of these tasks, relative to their output, changes as the program moves through the various phases of the acquisition process (see table 3-1). Generally the activity moves from analysis, to initial recommendations, to firm commitment to a given support approach, resulting in actions to provide the needed resources (equipment, parts, training, facilities, etc.). Throughout the entire process, cost of quality will be incurred. Examples of these costs are given below.

Appraisal (evaluate, measure, or audit output)

- ILS milestone progress review
- Individual LSA analyses review
- Equipment design review
- Facilities plan/design review
- Technical data review
- Training material review

Failure (detection, disposition, rework, repair, scrap, correct nonconforming output)

Internal (before delivery)

- Planning errors
- LSA analysis not complete
- LSA analysis errors

- Facility power requirements not covered
- Technical training requirements overlooked
- Technical data schematic errors

External (after delivery)

- Errors in plan submitted to government
- Errors/omission from LSA documents
- Sneak circuit in test equipment
- Facility met the design, but is inadequate
- Technical order errors (typos, omissions, incorrect logic in trouble tree, etc.)
- Training not current with latest configuration of equipment

Prevention (avoid)

- Training of LSA analysts
- Up front planning
- Development of handbooks
- Debug/proofing of computer models prior to actual use in LSA effort
- Review of lessons learned

Now look at table 4-7-1 for a detailed breakout of typical major responsibilities, activities, drivers, and cost of quality measures for the logistics area. A worksheet to assist in capturing cost of quality is also provided.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
MAINTENANCE CONCEPT/ PLANNING	TENTATIVE MAINTENANCE CONCEPT SELECTED	PREVENTION - WELL THOUGHT OUT, EARLY DECISION	AFR 800-8	
	IDENTIFY MAINTENANCE OR REPAIR FLOAT NEEDED	FAILURE - CHANGE DECISION AFTER MUCH WORK HAS DONE BASED ON ORIGINAL DECISION		- CHANGE RATE PER INDIVIDUAL LSA SHEET DRIVEN BY DECISION CHANGE
RELIABILITY/AVAILABILITY/ MAINTAINABILITY (RAM)	QUANTITATIVE RAM NUMBERS TRANSLATE INTO FIELD RAM NUMBERS	APPRAISAL - REVIEW OF ANALYSIS, CONTENT, AND PROGRESS		- ERRORS PER ANALYSIS
SUPPORT AND TEST EQUIPMENT (STE)	IDENTIFY WHAT IS NEEDED (EXISTING, NEW, OR MODIFIED) SUPPORT EQUIPMENT TEST EQUIPMENT TOOLS	FAILURE - LACK OF ACCURATE EVALUATION OF EXIST- EQUIPMENT, TOOLS,	AFR 800-12	- DUPLICATES VERSUS TOTAL NUMBER OF ITEMS PROPOSED (AS A %)
SUPPLY SUPPORT/PROVISIONING	SPARE SYSTEMS OR MODULES PREPOSITIONED WAR RESERVE	PREVENTION - - LESSONS LEARNED - VALIDATION OF MODELS	MIL-S-1561 AFR 800-36	
		FAILURE - ITEMS NOT CONSIDERED THAT REQUIRE SPARES		- % ITEMS MISSING SPARES VERSUS TOTAL
PACKAGING, HANDLING, TRANSPORATION STORAGE (PHTS)	DESCRIBE PLANNED SYSTEM FOR PHTS - ADDRESS AIR/SEA/LAND	PREVENTION - LESSONS LEARNED		
		APPRAISAL - REVIEW PLANS AGAINST STATED NEED		- PLANNING ELEMENTS MISSED VERSUS TOTAL

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		FAILURE - SPECIAL AIRLIFT REQUIREMENTS NOT CONSIDERED		- % ERRORS PER PLAN SECTION
FACILITIES	IDENTIFY NEEDED FACILITIES	APPRAISAL - FACILITY DESIGN REVIEWS	AFR 800-8	- DRAWING ERROR RATE - LESSONS LEARNED ADOPTION
	DELINEATE PLANS TO SATISFY THESE REQUIREMENTS	FAILURE - DRAWING ERRORS PREVENTION - TRAINING; LESSONS LEARNED		
DATA	IDENTIFY DATA REQUIRED o FIELD USE - TECHNICAL MANUALS - OPERATING INSTRUCTIONS, ETC. o CONTRACT USE - DRAWINGS - REPORTS, ETC. PLAN DATA CALL	APPRAISAL - - T.O. VERIFICATION - DRAWING REVIEW - FIELD TESTS FAILURE - - EXCESS DATA REQUIRED - DATA ITEMS MISSED - INCOMPLETE DATA ITEMS	DODD 1000 TM 86-01	- T.O. ERRORS PER PAGE - DRAWING ERROR RATE - FIELD TEST ERRORS PER TEST RUN - DATA USAGE RATE - ACTUAL DATA REQUESTED VERSUS DATA CALL INPUT
MANPOWER AND PERSONNEL	IDENTIFY PEOPLE TO OPERATE, MAINTAIN, TEST, TRAIN, ETC. - BOTH NUMBERS AND TYPES IDENTIFY NEW SKILLS REQUIRED AND ANY INCREASE IN NUMBERS	PREVENTION - - ADEQUATE UP FRONT PLANNING - LESSONS LEARNED - USER INVOLVED UP FRONT APPRAISAL - - COURSE REVIEWS		

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
TRAINING AND TRAINING DEVICES	IDENTIFY POPULATION TO BE TRAINED PLAN TRAINING TRACKS IDENTIFY TRAINING SCHOOL IDENTIFY TRAINING SYSTEM	FAILURE - - CURRICULUM ERRORS - TRAINING MOCK UPS NOT IN CORRECT CONFIGURATION		- NATURE OF ERRORS - CRITICAL - MAJOR - MINOR

Table 4-7-1

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - LOGISTICS

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
ILS MILESTONE PROGRESS REVIEW							
INDIVIDUAL LSA ANALYSES REVIEW							
EQUIPMENT DESIGN REVIEW							
FACILITIES PLAN/ DESIGN REVIEW							
TECHNICAL DATA REVIEW							
TRAINING MATERIAL REVIEW							
INTERNAL FAILURE							
PLANNING ERRORS							
LSA ANALYSIS NOT COMPLETE							
LSA ANALYSIS ERRORS							
FACILITY POWER REQUIREMENTS NOT COVERED							
TECHNICAL TRAINING REQUIREMENTS OVERLOOKED							
TECHNICAL DATA SCHEMATIC ERRORS							

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - LOGISTICS

ACTIVITY	COVERED YES	COVERED NO	PROPOSED	ALLOWED	BASIS TRENDS	BASIS ACTUALS	BASIS JUDGE
EXTERNAL FAILURE							
ERRORS IN PLAN SUBMITTED TO GOVERNMENT							
ERRORS/OMISSION FROM LSA DOCUMENTS							
SNEAK CIRCUIT IN TEST EQUIPMENT							
FACILITY MET THE DESIGN, BUT IS INADEQUATE							
TECHNICAL ORDER ERRORS (TYPOS, OMISSIONS, INCORRECT LOGIC IN TROUBLE TREE, ETC.)							
TRAINING NOT CURRENT WITH LATEST CONFIGURATION OF EQUIPMENT							
PREVENTION							
TRAINING OF LSA ANALYSTS							
UP FRONT PLANNING							
DEVELOPMENT OF HANDBOOKS							
DEBUG/PROOFING OF COMPUTER MODELS PRIOR TO ACTUAL USE IN LSA EFFORT							
REVIEW OF LESSONS LEARNED							
TOTALS							

CONTRACTS

The contracts function makes a very substantial contribution to the cost of quality. Although the responsibilities of the contracts organization will probably vary from contractor to contractor, it generally is the primary legal link to the government. Through the contract, the terms and conditions, specifications, tasking and financial aspects of the contractor - government relationship become binding on both parties. The effect of errors in any of these elements can have a direct financial impact on both parties. A list of typical functions performed by contracts might look like this:

Proposal Preparation

Pricing

Negotiation

Contract Administration

Invoice/Progress Payment Submission

Although these functions may not always be performed by the contracts organization, they represent the range of functions that could be performed there.

By the very nature of these functions, extensive interaction with other areas is required in order to convert the government's request for proposal (RFP) into a profitable contract that meets the customer's requirements. Since contracts is generally the final link in the chain which establishes the legal relationship with the government, its contribution to the cost of quality can be significant. Errors committed in the pricing and negotiation of the contract are not easily remedied.

Following is a list of activities which become part of the cost of quality.

<u>Prevention</u>

- Training (administrative, technical, and management)
- Development of handbooks and aids to job performance
- Development of plans and strategy
- Team meetings and effective communication of plans and strategies

Appraisal

- Reviews of documents and negotiation positions
- Reviews of compliance with requirements
- Audits of pricing accuracy
- Reviews of submissions to the government

Internal Failure

- Errors in preparation of documents
- Negotiation errors
- Failure to meet internal milestones

External Failure

- Inaccurate or incomplete proposals or contracts
- Late proposals or contract submittals
- Defective pricing
- Incorrect submissions

Contract and correspondence files are good sources of information on external failures. Records relating to proposal activity may indicate where internal failures occurred during preparation of proposals. Requests for clarification or notices of deficiencies in proposals will indicate external failures. Depending on where such information is found, rejected progress payment requests, corrected requests, and rejected and corrected invoices will also indicate external failure. Additional information can always be obtained through interviews with persons involved with these activities. Table 4-8-1 describes the major responsibilities, activities and cost of quality for the contracts function. A guide for analysis of the cost of quality is provided by the functional area worksheet. It is not meant to be all inclusive, but is a starting point and must be adapted to each organization evaluated.

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
PROPOSAL PREPARATION	PLAN PROPOSAL ACTIVITY	PREVENTION - ENSURE RESPONSIVE PROPOSAL IS SUBMITTED ON TIME	RFP	- BID AND PROPOSAL COSTS
	DISSEMINATE RFP		RFP	
	PREPARE PROPOSAL		RFP	
	SUBMIT PROPOSAL		RFP	
		APPRAISAL - ENSURE PROPOSAL MEETS REQUIREMENTS	RFP	- PROPOSAL REJECTED AS NON-RESPONSIVE - COST OF CORRECTING PROPOSAL
PRICING	PRICE PROPOSED CONTRACTUAL EFFORT	PREVENTION - ENSURE EFFORT IS CORRECTLY PRICED	RFP	- OVERRUNS AND UNDERRUNS
		APPRAISAL - CHECK FOR ERRORS IN PRICING		- COST OF REQUIRED WORK INCORRECTLY PRICED
	UPDATE PRICING	PREVENTION - PROVIDE MOST CURRENT COMPLETE AND ACCURATE PRICING DATA TO NEGOTIATORS	PL 87-653	- POST AWARD AUDIT REPORTS
		APPRAISAL - LOOK FOR DATA NOT PROVIDED	PL 87-653	- COST OF RESPONDING TO AND SETTLING POST AWARD AUDITS

Table 4-3-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
NEGOTIATION	FACT FINDING			
	NEGOTIATE CONTRACT	PREVENTION - ENSURE SETTLEMENT IS ACCEPTABLE TO ALL AFFECTED ORGS.		
		APPRAISAL - REVIEW STRATEGY AND AND OFFERS FOR ERRORS		- COST OF NEGOTIATION PREPARATION
ADMINISTRATION	PREPARE AND/OR REVIEW PROPOSED CONTRACT DOCUMENT	PREVENTION - ENSURE NEGOTIATED AGREEMENT IS REFLECTED IN CONTRACT		
		APPRAISAL - CHECK FOR ERRORS AND INCONSISTENCIES BETWEEN NEGOTIATION RECORD AND CONTRACT		- NUMBER OF REWRITES OF DRAFT CONTRACT/ MODIFICATION - COST OF REWRITES
		FAILURE - ACTION TO CORRECT		- COST OF ACTION TAKEN TO CORRECT ERRORS OR - COST DUE TO ERRORS WHICH CANNOT BE CORRECTED
	DISSEMINATE CONTRACT REQUIREMENTS	PREVENTION - ENSURE INDIVIDUALS ARE AWARE OF THEIR CONTRACT REQUIRE-MENTS	CONTRACT	

Table 4-8-1

MAJOR RESPONSIBILITY	SPECIFIC ACTIVITY	COST OF QUALITY	DRIVERS	TYPICAL MEASURES
		APPRAISAL - REVIEW STATUS OF CONTRACT DELIVERABLES		- NUMBER OF DELINQUENT ITEMS - COST OF PAYMENTS WITHHELD
	TRANSMITTAL OF CONTRACT DELIVERABLES	PREVENTION - ENSURE ITEMS RECEIVED FROM OPRs ARE PROMPTLY SUBMITTED	CONTRACT	
		APPRAISAL - COMPARE ACTUAL AND REQUIRED SUBMISSION DATES		- NUMBER OF LATE SUBMITTALS
INVOICING	SUBMIT PROGRESS PAYMENT REQUESTS AND INVOICES	PREVENTION - ENSURE REQUESTS ARE CORRECT AND TIMELY	CONTRACT/ FAR	
		APPRAISAL - CHECK DATA FOR ACCURACY		- NUMBER OF CORRECTIONS REQUIRED - COST OF CORRECTING ERRORS
		FAILURE - RESUBMIT REJECTED PROGRESS PAYMENT REQUESTS		- NUMBER OF REJECTED PROGRAM PAYMENT REQUESTS - COST OF RESUBMISSION - LOST INTEREST ON PROGRESS PAYMENTS

Table 4-8-1

4-8-5

COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - CONTRACTS

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
APPRAISAL							
PRE NEGOTIATION REVIEWS							
CONTRACT DOCUMENT REVIEW							
CHECK PROPOSAL VS. RFP							
CHECK FOR PRICING ERRORS							
CHECK FOR CURRENT PRICING DATA NOT SUBMITTED							
REVIEW STATUS OF CONTRACT DELIVERABLES							
COMPARE ACTUAL AND REQUIRED DELIVERY DATES							
CHECK INVOICES/ PROGRESS PAYMENT REQUESTS FOR ACCURACY							
INTERNAL FAILURE							
PROPOSAL ERRORS PRIOR TO SUBMISSION							
NEGOTIATION ERRORS							
CONTRACT ERRORS PRIOR TO SIGNATURE							
INVOICE/PROGRESS PAYMENT ERRORS DUE TO SUBMISSION							

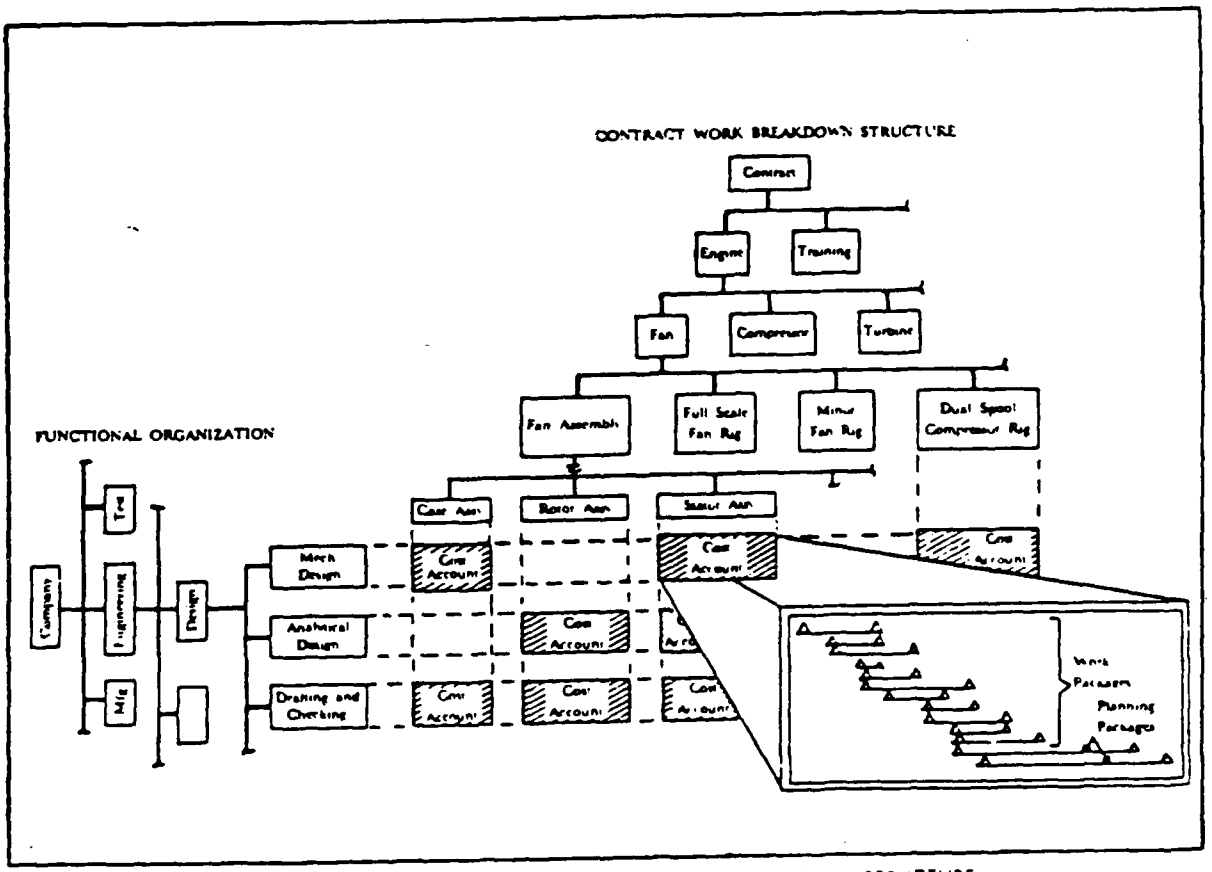
COST OF QUALITY FUNCTIONAL AREA WORKSHEET

FUNCTIONAL AREA - CONTRACTS

ACTIVITY	COVERED		PROPOSED	ALLOWED	BASIS		
	YES	NO			TRENDS	ACTUALS	JUDGE
EXTERNAL FAILURE							
PROPOSAL ERRORS AFTER SUBMISSION							
POST AWARD AUDIT REPORTS (DEFECTIVE PRICING)							
CORRECTIONS TO CONTRACTS							
CLAIMS							
LAWSUITS							
LATE PROPOSALS							
REJECTED OR DELAYED PROGRESS PAYMENT REQUESTS							
REJECTED INVOICES OR DELAYED PAYMENT							
PREVENTION							
TRAINING							
DEVELOP HANDBOOKS, CHECKLISTS, AND GUIDES							
PROPOSAL/ NEGOTIATION MEETINGS AND PLANS							
COORDINATION OF NEGOTIATION POSITION/STRATEGY							
TOTALS							

IMPLEMENTATION

Programs which call for cost and schedule reporting as a contractual requirement provide a ready source for first, getting visibility into specific costs of quality, and second, monitoring those expenditures. Looking at the way that the contractor typically generates the cost data, it is obvious that referring to the individual work packages is one step toward finding readily available cost data (figure 5-1).



INTEGRATION OF CWBS AND ORGANIZATIONAL STRUCTURE.

Figure 5-1

Work packages constitute the basic building blocks used by the contractor in planning, controlling, and measuring contract performance. In addition, if the contractor has established cost accounts, at a level just above work packages in his contractor work breakdown structure, then detailed costs from both a proposed and actual view may be available. Keep in mind that all direct costs are accumulated in cost accounts. Current criteria do not require recording of indirect costs at this level. However, overhead pools and corresponding budgets must be designated and the methods used for allocation clearly defined and documented. Unfortunately, level of effort work has no established criteria for determination of acceptable levels. Often we find that the work involved with cost of quality is level of effort. For example:

Engineering

- FRACAS

Quality

- QA Engineering problem solving

Once cost analysis has been performed and the costs proposed have been evaluated, the negotiations completed, and a contract awarded, performance against the budget is tracked. From a cost of quality point of view, we are concerned that the costs expended produce the desired results. The desired results are achievement of the contractual quality requirements, that is, the establishment and implementation of an effective and efficient quality program. Effectiveness is measured by the performance indication discussed in Chapter one and outlined in table 1-4. The trends must reflect that the quality effort is achieving an acceptable level of quality and is improving that level over time. Each functional analyst's professional judgment must be applied to determine the acceptability of the level of budgeted resources. Efficiency is measured by whether the resources being expended are the optimum for the results achieved.

Focus must be placed on analysis of variances that occur between budgeted and actual costs over the life of the contract. If quality performance indicators are high, or trends are up, the analyst must verify that the planned resources, assuming analysis showed their level to be correct, are indeed being applied. Using the techniques and worksheets described in each of the individual functional sections in Chapter five is the next step.

Programs covered by MIL-STD-1567A, Work Measurement, offer another source of data that is useful in cost of quality analysis. The essence of work measurement can be summed up in the

concepts of variance analysis and methods improvement. Once engineered standards have been established for work performed, analysis of those variances that occur from the standard should be aimed at finding and eliminating the cause of the variance. If the contractor's actuals show a consistent performance level above the standard hour content, the variance allowance can reveal cost of quality contribution. For example, is the process so difficult to control, to ensure that it produces conforming product, that extra care and time is needed by the operator, thus causing the variance from standard? This is a prevention cost contributor. If the variance is due to excessive rework or repair action, this is a failure cost contributor. Looking at the variance analysis can be very helpful when doing cost of quality analysis. In addition, if the contractor puts into place methods improvements, besides the expected benefit of lowering the standard, the result may well be a more capable and controllable process. Contribution to the prevention of errors is evident. The initial investment, or a portion thereof, can be legitimately counted as a cost of quality. Training of operators, both to better control the old process, or properly implement the new methods, is also prevention cost of quality.

POSSIBLE CONTRACTUAL CLAUSE APPROACHES

In its present form, MIL-Q-9858A, paragraph 3.6, which clearly establishes the requirement for collecting and making available cost of quality data, is subject to a good deal of interpretation. As discussed under requirements in Chapter two, pages 2-6 and 2-7, even the government's interpretation has sent a message to contractors that FAILURE costs associated with scrap, rework, and repair are the only costs actually required. Turning to MIL-STD-1520C, the requirement also is specific on failure cost, but leaves selection of "other costs as determined appropriate by the contractor". At this time, the best way to obtain the desired cost of quality effort on the part of a contractor, assuming he is not willing to adopt a wider interpretation of existing requirements, is through specific contractual language.

There are several approaches that could be used when considering how to both obtain the desired results and to positively motivate the contractor to perform in the manner that maximizes benefits of using cost of quality as a management tool. Request for proposal instructions to offeror must provide proper emphasis. After investigating various options, the methods recommended here consist of suggested contractual clauses, statement of work provisions, or combinations of both. It is generally agreed that profit is an effective motivator. Offering a contractor an award fee, based on performance in the cost of quality management area, then becomes one approach. Getting a contractor into a "prevention mode" will have significant benefits for the life cycle costs of his product, and would more than offset the cost of the award fee. Making the fee a portion of the profit allowed on the contract then ties it to the normal cost experienced by the government, as opposed to an "over and above" amount. But

offering an over and above amount could also enhance the motivational effectiveness of the fee. Obviously, it increases the initial cost to the government, but again, the overall reduction in life cycle costs will more than offset this front end increase. In addition, the total cost of quality, as discussed in Chapter one, figure 1-15, will decrease as the contractor gets into the prevention mode, thus offsetting the cost of any award fee.

What follows are examples of "suggested" contract clauses, and statement of work provisions. Appendix E provides copies of actual award fee wording from two contracts used in Air Force programs. The program identifying characteristics have been removed from each example. A logical consideration to follow an award fee program, designed to get the contractor's management focus on moving towards a prevention mode, would be a shared savings program. Approaches currently used in the industrial modernization incentive program could be modified. Once the focus was on prevention, the reductions obtained in the cost of quality total could then be shared. The share approach could take a variety of forms, and could be tied to other factors such as improving reliability and/or reduction in field failures. Total cost of quality can run anywhere from 10% to 30% of sales, so shared reductions represents a significant amount of money.

SUGGESTED CONTRACTUAL CLAUSES

In order to ensure that the contractor captures cost of quality in all the categories, i.e., prevention, appraisal, and internal and external failure, the following clauses are suggested.

CLEAR DEFINITION OF COST OF QUALITY DATA

"Cost of Quality. For the purposes of this contract, the contractor shall capture cost of quality under MIL-Q-9858A, paragraph 3.6 in a manner which segregates the cost for prevention of defective output and the correction of defective output (to be referred to as failure costs). Under paragraph 3.4, the contractor shall capture the costs associated with the effort expended to generate the quality information for which records are required, i.e., the appraisal of the processes which result in the final product. These costs shall be made available under authority of paragraph 3.6. The requirement for prevention and correction costs is clearly stated in paragraph 3.6. Costs associated with appraisal activity necessary to produce the records of quality status essentially represent the costs associated with the quality department inspection, audit, and test resources. Under authority of paragraph 3.5, these costs of quality will be used by the contractor as a management tool to assist in exercising responsibilities for detection, correction of assignable causes across the entire organization as well as at suppliers, trend analysis aimed at prevention, and monitoring of the effectiveness of corrective action".

INCLUSION OF SPECIFIC REQUIREMENTS DRIVING COST OF QUALITY

"Beyond requirements covered under MIL-Q-9858A, the contractor shall segregate all costs associated with the following efforts, as applicable, and include these costs as part of his cost of quality management program:

MIL-STD-1520C	Correction of Non-Conforming Material
MIL-STD-45662	Metrology
MIL-STD-1535A	Control of Subcontractor quality
*MIL-STD-1567A	Work Measurement
*MIL-STD-1528A	Manufacturing Management
MIL-STD-100	Engineering Drawings
MIL-STD-810D	FRACAS/FMEA
	Environmental Stress Screening
	Hardware Quality Audit
	Statistical Process Control

*Only the costs of collecting data, evaluating it, and acting to correct and prevent problems. Does not include cost of establishing the work measurement or manufacturing management program.

These costs shall include effort expended by all functions associated with the accomplishment of the specific tasks driven by these government specifications/standards."

STATEMENT OF WORK PROVISION

If the use of either of these suggested clauses is not suitable, another option would be to specify what is required in the statement of work.

STATEMENT OF WORK

COST OF QUALITY PROGRAM. The contractor shall establish a Cost of Quality Program for each business unit performing work under this contract. The purpose is to provide management tools to enable the contractor to move from a reactive "find and fix" quality mode to a "preventative" mode. The contractor shall comply with the provisions of Annex _____. (DI-X-XXXX (Plan)) and (DI-X-X-XXXX (COQ Report)).

ANNEX _____

COST OF QUALITY

Purpose. The purpose of this annex is to specify the general program and requirements for the Cost of Quality Program.

Scope.

Introduction. The traditional view of the Cost of Quality is focused on the costs of scrap, rework and repair or more correctly, the cost of failure. By viewing only the costs of failure, this traditional approach has prevented us from identifying the true cost of quality and, therefore, has not helped to identify the root causes of poor quality. A more useful approach to the cost of quality considers not only the cost of failure, but also the costs of appraisal and prevention. Additionally, failure costs are subdivided into external failures and internal failures. Cost of quality is one of the management tools available for use in improving the overall quality of the goods and services purchased by the Department of the Air Force. Specifically, it:

- provides visibility into the total cost of ensuring quality requirements are being met.
- points to problems in the quality program that are reflected in cost of quality category imbalances, or excessive cost in non-value added activities.
- acts as a diagnostic tool at lower organizational levels in identifying problem areas.
- allows judgments about the real thrust of a given effort to achieve quality from the perspective of "inspecting quality in" versus "designing and building quality in".
- allows management to judge the effectiveness of corrective actions taken to eliminate the root causes and improve product quality.

Definitions.

a. Output - result or tangible product of any process (design, purchasing, manufacturing, etc.)

b. Cost of Quality - the cost of all efforts expended to find non-conforming output, react to actual failures, both internally and externally, and to prevent failures from happening in the first place.

c. Appraisal Costs - costs expended in the effort to find non-conforming output. (See Page 1-1, this handbook.)

d. Failure Costs - the cost of actual failures themselves are called internal failure and external failure costs.

e. Prevention Costs - the cost of efforts designed to stop problems or failures from occurring in the first place.

Implementation Plan. The contractor shall develop a cost of quality implementation plan covering each major business unit performing work under this contact.

Purpose. The purpose of the implementation plan is threefold -

1. Promote a Cost of Quality culture within the organization. This culture is built on the recognition that everyone in the organization contributes to the ultimate quality of the organization's output and that the customers defines quality.

2. Define the Cost of Quality for the organization and the system designed to capture it.

3. Assign tasking for overall management of the plan as well as for the actual collection of the cost of quality data.

Specific Requirements

1. The plan shall be unique to the contractor so as to be readily used by management of each affected organizational element.

2. Although the plan will be unique, it should be tailored along the lines of accepted, existing programs such as the American Society for Quality Control's "Principles of Quality Cost".

3. The plan must identify the cost of quality by identifying and listing all quality related activities under the general categories of Prevention, Appraisal, Internal Failure, and External Failure.

4. The plan must describe how the costs of these quality related activities will be captured and reported.

5. The plan must also describe how management will use the reported information to move from the traditional "find and fix" reaction mode to one of "prevention".

Measures.

The final section of the implementation plan shall establish measures, in terms of cost of quality, which will document the progress in moving toward a totally "preventative" quality environment. Improvement indicated by these measures must be verifiable by the contracting officer with the assistance of the CAO and/or DCAA. (Note: Use caution if "goals" are proposed. Merely achieving cost reductions is not the primary intent of capturing cost of quality data.)

Award Fee.

Because of the importance of high quality in the goods and services purchased by the Department of the Air Force, the government may, in selected instances, incentivize a contractor's management of the cost of quality through use of an Award Fee provision.

Specifications and Standards.

MIL-Q-9858A

MIL-STD-1520C

MIL-STD-1535A

MIL-STD-1567A

MIL-STD-1528A

GLOSSARY OF TERMS

ACCEPTANCE - The act of an authorized representative of the government by which the government assumes for itself, or as agent of another, ownership of existing and identified supplies tendered or approves specific services rendered, as partial or complete performance of the contract on the part of the contractor.

ACTUAL COST - The sum of the allowable direct and indirect costs (allocable) incurred as a result of producing a part, product, or service.

BASELINE COST ESTIMATE (BCE) - A document which is a deliberate detailed estimate of acquisition and ownership costs.

CALIBRATION - The comparison of a measurement system or device of unverified accuracy to a measurement system or device of known or greater accuracy to detect and correct any variation from required performance specifications of the unverified measurement system or device.

CONFIGURATION - The functional and/or physical characteristics of hardware/computer programs as set forth in technical documentation and achieved in a product.

COST CENTER - Any subdivision of an organization comprised of workers, equipment areas, activities, or combination of these that is established for the purpose of assigning or allocating costs. Cost centers are also used as a base for performance standards. Synonym: burden center, cost pool.

COST ESTIMATING RELATIONSHIP (CER) - The curve of a cost function which relates the cost of a product to some measurable characteristic of its manufacture and from which extrapolations and interpolations may be extracted for estimating purposes.

COST OF QUALITY - The costs of all efforts expended to find non-conforming output , react to actual failures, both internally and externally, and to prevent failures from happening in the first place.

Appraisal Costs - The costs expended in the effort to find non-conforming output.

Prevention Costs - The costs of efforts designed to stop problems or failures from occurring.

Internal Failure Costs - The costs incurred for identified failures prior to final delivery of the specific output to the customer.

External Failure Costs - The costs incurred for a specific output that fails after delivery to the customer.

CRITICAL WEAKNESS RELIABILITY TEST - This test determines the mode of failure when equipment is exposed to environments in excess of the anticipated environments. By this testing, critical levels can be determined from vibration, temperature voltage, cycles, etc., which will adversely affect the component. In subsequent tests of the total system in which a stress level exceeds the expected limits, an evaluation of the critical weakness tests will provide excellent insight as to what may have been damaged or what can be expected to fail.

DEMONSTRATION VALIDATION/RISK REDUCTION - The period when major program characteristics are refined through extensive study and analysis, hardware development, test and evaluations. The objective is to validate the choice of alternatives and to provide the basis for determining whether or not to proceed into full-scale development.

DESIGN TO COST - A process utilizing unit cost goals as thresholds for managers and design parameters for engineers normally in terms of a single cumulative "average flyaway cost". This cost represents what the government has determined it can afford to pay for a unit of military equipment which meets established and measurable performance requirements at a specified production quantity and rate during a specified period of time.

DESIGN TO COST GOAL - A specific cost established as a goal for a specific configuration, established performance characteristics and a specific number of systems at a defined production rate.

DIRECT COST - Those costs which can be traced directly to a specific piece-part, subassembly, or product.

DIRECT ENGINEERING - Engineering effort directly traceable to the design, manufacture, or control of specific end products.

DIRECT LABOR STANDARD - A specified output or a time allowance established for a direct labor operation.

DIRECT MANUFACTURING LABOR - Work which alters the composition, condition, conformation, or construction of the product; the cost of which can be identified with and assessed against a particular part, product, or group of parts or products accurately and without undue effort and expense; coloquially called "direct labor".

DIRECT MATERIAL - All material that enter into and becomes part of the finished product (including waste), the cost of which can be identified with and assessed against a particular part, product, or group of parts or products accurately and without undue effort and expense.

EFFICIENCY FACTOR - The ratio of standard performance time to actual performance time, usually expressed as a percentage.

FAILURE - The event in which any part of an item does not perform as required by its performance specification.

FIXED COST - Those costs which remain relatively constant irrespective of volume.

FLOW DIAGRAM - The paths of movement of workers and/or materials super-imposed on a graphical representation of a work area.

FLOW PROCESS CHART - A graphic representation of the sequence of all operations, transportations, inspections, delays, and storages occurring during a process or procedure.

FLOW TIME - The time required for a defined amount of work to be completed.

GANTT CHART - A graphic representation of a time scale of the current relationship between actual and planned performance.

GENERAL AND ADMINISTRATIVE COSTS (G&A) - An overhead cost category for accumulation of such costs as personnel department, accounting, purchasing, etc.

GOVERNMENT ACQUISITION QUALITY ASSURANCE - The function by which the government determines whether a contractor has fulfilled his contract obligations pertaining to quality and quantity.

IDLE TIME - A time interval during which either the workman, the equipment, or both do not perform useful work.

IN PROCESS INVENTORY CONTROL - The process whereby materials and parts are effectively and efficiently planned and controlled to assure their availability at the required stage or production.

INDEPENDENT COST ANALYSIS (ICA) - An analysis of program cost estimates conducted by an impartial body disassociated from the management of the program.

INDEPENDENT COST ESTIMATE (ICE) - The government's cost estimate used for program approvals, for establishing budget estimates and as a baseline for evaluating offerors proposals. The ICE should be an independent, objective unbiased estimate which stands on its own as a "yardstick" for evaluating offerors proposals.

INDIRECT COST - Costs necessary in manufacturing which cannot be readily identified with or changed to a particular part, product, or group of parts or products.

INDIRECT LABOR - Work which is performed rendering services necessary to production, the cost of which cannot be assessed against any part, product, or group of parts or products accurately or without undue effort and expense.

INDIRECT MATERIAL - Material consumed in the process of production or manufacture that does not become a part of the finished product and/or cannot be readily identified with or changed to a particular part, product, or group of parts or products.

INDIVIDUAL ACCEPTANCE TEST - This is based on a test of predetermined critical items to verify their operational characteristics prior to assembly into subsystems. Waivers to this requirement such as using the end item acceptance tests is not recommended as production expediency. This test should be capable of being performed on the same fixtures used for preceding type tests.

INDUSTRIAL ENGINEERING - The art and science of utilizing and coordinating workers, equipment, and materials to attain a desired quantity of output at a specified time and at an optimum cost. This may include gathering, analyzing, and acting upon facts pertaining to building and facilities, layouts, personnel organization, operating procedures, methods, processes, schedules, time standards, wage rates, wage payment plans, costs, and systems for controlling the quality of goods and services.

INHERENT R & M VALUE - Any measure of reliability or maintainability that includes only the effects of item design and installation, and assumes an ideal operating and support environment.

INSPECTION - The examination and testing of supplies and services (including, when appropriate, raw materials, components, and intermediate assemblies) to determine whether they conform to specified requirements.

JOB ORDER COST SYSTEM - Direct and overhead cost data are accumulated by each contract or order.

LABOR PRODUCTIVITY - The rate of output of a workman or group of workers per unit of time, usually compared to an established standard or expected rate of output.

LABOR STANDARDS - A compilation by time study of standard time for each element of a given type of work. Once element standards have been established, the standards are applied to work containing similar elements without making actual time studies of the work.

LIFE CYCLE COST - The Life Cycle Cost (LCC) of a system is the total cost to the government of acquisition and ownership of that system over its full life. It includes the cost of development, acquisition, support and, where applicable, disposal.

LINE OF BALANCE - A graphic display of scheduled units versus actual units over a given set of critical schedule control points on a particular day.

MAINTAINABILITY - The ability of an item to be retained in or

restored to specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair.

MANPOWER SCHEDULING AND LOADING - The effective and efficient utilization and scheduling of available manpower according to their skills to ensure that required manufacturing operations are properly coordinated and executed.

MANTECH (MANUFACTURING TECHNOLOGY) - Manufacturing Technology refers to any action which has its objective, 1) the timely establishment or improvement of the manufacturing processes, techniques, or equipment required to support current and projected programs, and 2) the assurance of the ability to produce, reduce lead time, ensure economic availability of end items, reduce costs, increase efficiency, improve reliability, or to enhance safety and anti-pollution measures.

MANUFACTURING OVERHEAD - A form of indirect costs - accumulated manufacturing costs prorated over all products in process, generally as a percent of direct labor and/or material.

MATERIAL - Property which may be incorporated into or attached to an end item to be delivered under a contract or which may be consumed or expended in the performance of a contract. It includes, but is not limited to, raw and processed material, parts, components, assemblies, fuels and lubricants and small tool and supplies which may be consumed in normal use in the performance of a contract.

METHODS ENGINEERING - The technique that subjects each operation of a given piece of work to close analysis in order to eliminate every unnecessary element or operation and in order to approach the quickest and best method of performing each necessary element or operation. It includes the improvement and standardization of methods, equipment, and working conditions; operator training; the determination of standard times; and occasionally devising and administering various incentive plans.

METHODS STUDY - Systematic recording of all activities performed in a job or position of work including standard times for the work performed. Work simplification notes are written during the study.

METROLOGY - The science of weights and measures used to determine conformance to technical requirements including the development of standards and systems for absolute and relative measurements.

NONRECURRING - A descriptive term applied to a type of work, operation, part, or the like that does not recur frequently or in any reasonable regular sequence (also nonrepetitive).

OPERATION PROCESS CHART - Identifies the successive operations, in their required sequence, for producing a product (component).

OPERATIONAL R & M VALUE - Any measure of reliability or maintainability that includes the combined effects of item design, quality, installation, environment, operation, maintenance, and repair.

PROCESS - 1) A planned series of actions of operations which advances a material or procedure from one stage of completion to another, and 2) a planned and controlled treatment that subjects materials to the influence of one or more types of energy for the time required to bring about the desired reactions or results.

PROCESS COST SYSTEM - Total costs for producing a type of unit. The number produced are determined for regular accounting periods and an average unit. The cost based on that data is determined.

PRODUCIBILITY - The relative ease of producing an item or system which is governed by the characteristics and features of a design that enable economical fabrication, assembly, inspection, and testing using available production technology.

PRODUCIBILITY ENGINEERING AND PLANNING (PEP) - The production engineering tasks and production planning measures undertaken to ensure a timely and economic transition from development to the production phase of a program.

PRODUCTION MANAGEMENT - The effective use of resources to produce on schedule the required number of end items that meet specified quality, performance, and cost. Production management includes but is not limited to industrial resource analysis, producibility assessment, producibility engineering and planning, production engineering, industrial preparedness planning, post-production planning, and productivity enhancements.

PRODUCTION PLANNING - The systematic scheduling of workers, materials, and machines by using lead times, time standards, delivery dates, work loads, and similar data for the purpose of producing products efficiently and economically and meeting desired delivery dates.

PRODUCTION PLANNING AND CONTROL - The planning of operations that accomplishes coordination of workers, material, and facilities to achieve effective and efficient production goals.

PRODUCTION READINESS REVIEW (PRR) - A formal examination of a program to determine whether the design is ready for production, production engineering problems have been resolved, and the producer has accomplished adequate planning for the production phase.

PRODUCTIVITY - The actual rate of output or production per unit of time worked.

PRODUCTS - All items, materiel, material, data, software, supplies, systems, assemblies, subassemblies, or portions thereof

which are produced, purchased, developed or otherwise used by DoD.

QUALITY ASSURANCE - A planned and systematic pattern of all actions necessary to provide confidence that adequate technical requirements are established; products and services conform to established technical requirements; and satisfactory performance is achieved.

QUALITY OF CONFORMANCE - The extent to which the product or system conforms to design criteria or requirements.

QUALITY OF DESIGN - The adequacy of the product or system design to meet the needs of the user.

QUALITY IMPROVEMENT - The emphasis on continual reduction of quality costs, regardless of the starting point.

QUALITY PROGRAM - A program which is developed, planned, and managed to carry out, cost-effectively, all efforts to effect the quality of materiel and services from concept through validation, full-scale development, production, deployment, and disposal.

R & M ACCOUNTING - That set of mathematical tasks which establish and allocate quantitative R & M requirements, and predict and measure quantitative R & M achievements.

R & M ENGINEERING - That set of design, development, and manufacturing tasks by which R & M are achieved.

RELIABILITY - The duration or probability of failure free performance under stated conditions.

REALIZATION FACTOR - The ratio of actual performance time to standard performance time, usually expressed as a decimal number.

REWORK - Any corrections of defective work either before, during or after inspection.

SCRAP - Residual material resulting from machine or assembly processes, such as machine shavings, unusable lengths of wire, faulty parts.

SET UP TIME - The time required to arrange locating fixtures and equipment in order to begin productive work; including adjustments and take down of the original set up.

SHRINKAGE - An additional quantity of material added to the quantity listed on the Bill of Material to provide for spoilage, scrap, waste and natural attrition (See: Attrition).

SOURCE SELECTION - The process wherein the requirements, facts, recommendations and government policy relevant to an award decision in a competitive procurement of a system/project are examined and the decision made.

SPOILAGE - A form of waste material resulting from misuse of material or errors in workmanship.

STANDARD - A term applied, in work measurement, to any established or accepted rule, model, or criterion against which comparisons are made.

STANDARD COST - The normal expected cost of an operation, process, or product including labor, material, and overhead charges, computed on the basis of past performance costs, estimates, or work measurement.

SYSTEM EFFECTIVENESS - The measure of the degree to which the hardware and software achieve the mission requirements in the operational environment as evidenced in system availability, dependability, and capability.

SYSTEM R & M PARAMETER - A measure of reliability or maintainability in which the units of measurement are directly related to operational readiness, mission success, maintenance manpower cost, or logistic support cost.

TECHNOLOGY MODERNIZATION - The coupling of modernization with the implementation of advanced manufacturing technology by providing incentives for contractor (and subcontractor) capitalization.

TESTING - An element of inspection. Generally denotes the determination by technical means of the properties or elements of supplies, or components thereof, including functional operation, and involves the application of established scientific principles and procedures.

TOUCH LABOR - Defined as production labor which can be reasonably and consistently related directly to a unit of work being manufactured, processed, or tested. It involves work affecting the composition, condition, or production of a product; it may also be referred to as hands on labor or factory labor. It includes such functions as machining, welding, fabricating, painting, assembling, and functional testing of production articles.

VARIABLE EXPENSE - Expenditures that vary in proportion to the volume of production, such that an increase/decrease in production causes an increase/decrease in the variable cost.

VARIANCE - The difference between any standard or expected value and an actual value. For example, the difference between the established standard cost and the cost actually incurred in performing a job or operation.

WORK SAMPLING STUDY - A statistical sampling technique employed to determine the proportion of delays or other classifications of activity present in the total work cycle.

BIBLIOGRAPHY

1. **ACCOMPLISHMENT COST: BETTER PROJECT CONTROL**
1971 BLOCK ELLERY B HARVARD BUSINESS REVIEW

2. **ACCOUNTING FOR THE REAL COST OF QUALITY**
QUALITY PROGRESS 22-27 1986 LENANE DEAN-MICHAEL

3. **ACCOUNTING GUIDE FOR GOVERNMENT CONTRACTS**
SEVENTH EDITION 1982 TRUEGER PAUL M COMMERCE CLEARING HOUSE INC

4. **ACE SYSTEM THAT IMPROVES QUALITY & PROFITS, AN**
ASQC 38TH ANNUAL QUALITY CONGRESS 295-30 1984 TUTTLE JOHN P MILLIPORE CORP BEDFORD MA 01730

5. **ACE: A SYSTEM THAT IMPROVES QUALTIY AND PROFITS**
QUALITY PROGRESS 59-61 1985 TUTTLE JOHN P

6. **AFTER THE COMMITMENT, THEN WHAT?**
ASQC 35TH ANNUAL QUALITY CONGRESS 897-90 1981 HAGAN JOHN T DIRECTOR-QUALITY MANAGEMENT ITT CORPORATION NEW YORK NY

7. **AIR FORCE POLICY LETTER FOR COMMANDERS AFRP**
190-1 1987

8. **AMA MANAGEMENT HANDBOOK**
HD31 A418 1983 FALLON WILLIAM K AMERICAN MANAGEMENT ASSOC

9. **AMERICAN QUALITY AND PRODUCTIVITY IN PERSPECTIVE**
ASQC 36TH ANNUAL QUALITY CONGRESS 475-48 1982 LANGEVIN ROGER G ARGYLE ASSOCIATES, INC. SOUTH SALEM NY

10. **AN ENGINEERING ORGANIZATION'S COST OF QUALITY PROGRAM**
QUALITY PROGRESS 29-34 1986 SCHRADER LAWRENCE J

11. **APPLICATION OF ECONOMIC PRINCIPLES TO QUALITY**
ASQC 38TH ANNUAL QUALITY CONGRESS 3-9 1984 BRADSHAW, JR CHARLES W WESTERN ELECTRIC COMPANY RICHMOND VA 23150

12. **ASSURANCE OF AVAILABILITY AND LIFE CYCLE COSTS**
ASQC 36TH ANNUAL QUALITY CONGRESS 465-47 1982 MAYBEN J E GENERAL DYNAMICS FORT WORTH TX

13. **ATTAINING MANUFACTURING EXCELLENCE**
LOC-86-7192 1987 HALL ROBERT W DON JONES-IRWIN

14. **BANKING QUALITY COST MODEL, ITS USES AND RESULTS, A**
ASQC 36TH ANNUAL QUALITY CONGRESS 195-20 1982 AUBREY, II CHARLES A MANAGER, QUALITY ASSURANCE CONTINENTAL ILLINOIS NATIONAL CHICAGO IL ZIMPLER DEBRA A QUALITY CONTROL ANALYST

15. **BETTER PRODUCTS AT LOWER COSTS**
JOINT ENGINEERING MANAGEMENT CONFERENCE 45-53 1972 SHECTER EDWIN S

16. **BUSINESS MANAGEMENT AND QUALITY COST**
QUALITY PROGRESS 13-18 1985 HITOSH KUME

17. **CAN QUALITY COST PRINCIPLES BE APPLIED TO PRODUCT LIABILITY**
ASQC 33RD ANNUAL QUALITY CONGRESS 295-29 1979 SHAININ DORIAN CONSULTANT DORIAN SHAININ CONSULTANTS INC

18. **COMMIT TO QUALITY**
HD66T65 1986 TOWNSEND PATRICK L JOHN WILEY & SONS, INC. GEBBARDT JOAN E

19. **CORRECTIVE ACTION IS MAGIC**
ASQC 38TH ANNUAL QUALITY CONGRESS 41-45 1984 SEISSER RICHARD J DIRECTOR OF QUALITY ASSURANCE GENERAL INSTRUMENT CORP

20. **COST OF QUALITY**
DLA CAMERON STATION 1987 DEFENSE CONTRACT ADM SERV ALEXANDRIA VA 22304 6100

21. **COST OF QUALITY IN THE SERVICE INDUSTRIES**
ASQC 32ND ANNUAL QUALITY CONGRESS 321-32 1978 ROSENZWEIG GEORGE VICE-PRESIDENT TECHNITROL TESTING LAB LTD. MISSISSAUGA ON

22. **COST OF QUALITY SYSTEM - A MANAGEMENT TOOL**
ASQC 37TH ANNUAL QUALITY CONGRESS 378-38 1983 DEMETRIOU JAMES MANAGER OF QUALTIY ADMIN ITT AVIONICS DIVISION CLIFTON NJ 07014

23. **COST OF QUALITY, THE**
TS156G76 GROOCOCK J M PITMAN PUBLISHING

24. **COST OF SOFTWARE QUALITY ASSURANCE, THE**
ASQC 35TH ANNUAL QUALITY CONGRESS 684-68 1981 GOELLER W O QUALITY MANAGER-PRIME PROGRAMS VOUGHT CORP DALLAS TX

25. **COST OPTIMIZED QA FOR COMMERCIAL CONSTRUCTION**
ASQC 39TH ANNUAL QUALITY CONGRESS 228-23 1985 ROBERTS ALLEN T ALLEN ROBERTS CONSULTATIONS RINGWOOD NJ 07456

26. **COST REDUCTION THROUGH QUALITY MANAGEMENT**
ASQC 35TH ANNUAL QUALITY CONGRESS 270-27 1980 SCANLON FRANK SECRETARY-DIRECTOR QUALITY THE HARTFORD INSURANCE GROUP

27. **COSTING QUALITY FOR SENSITIVITY ANALYSIS**
ASQC 40TH ANNUAL QUALITY CONGRESS 707-71 1986 KROEHLING HUGH E QUALITY CONTROL ENGINEER AT&T TECHNOLOGIES RICHMOND VA 23231 PETRSEL LAWRENCE R

28. **CUSTOMER-BASED MEASUREMENT CLOSE TO THE LOOP**
ASQC 35TH ANNUAL QUALITY CONGRESS 675-68 1981 UTZIG LAWRENCE J CONSULTANT-PRODUCT QUALITY GENERAL ELECTRONIC COMPANY FAIRFIELD CT 06431

29. **CUTTING THE COST OF QUALITY**
FARNSWORTH PUBLISHING INC 1967 CROSBY PHILLIP B INDUSTRIAL EDUCATION INSTITUTE

30. **DEALING WITH THE HUMAN SIDE OF QUALITY IMPROVEMENT**
ASQC 33RD ANNUAL QUALITY CONGRESS 763-76 1979 POLLARD, CMC JOHN W PRINCIPAL RATH & STRON, INC. LEXINGTON MA 02173

31. **DESIGN AND MANAGE TO LIFE CYCLE COST**
1978 BLANCHARD BENJAMIN S VIRGINIA POLYTECHNIC

32. **DESIGNING AN EFFECTIVE PROCUREMENT RATING SYSTEM**
ASQC 34TH ANNUAL QUALITY CONGRESS 488-49 1980 DOBBINS RICHARD K PRINCIPAL SYSTEMS ENGINEER HONEYWELL, INC. FORT WASHINGTON PA

33. **DISCOUNTED AND PER UNIT COSTS OF PRODUCT WARRANTY**
MANAGEMENT SCIENCE VOL 33 NO 7 916-93 1987 MAMER JOHN W

34. **EXTENDING EFFECTIVENESS OF QUALITY COST PROGRAMS**
ASQC 32ND ANNUAL QUALITY CONGRESS 200-20 1978 DOBBINS RICHARD K PRINCI QUAL ASSUR STAFF ENG HONEYWELL INC FORT WASHINGTON PA

35. **FAIRFIELD REPUBLIC COMPANY QUALITY COST PROGRAM, THE**
ASQC 33RD ANNUAL QUALITY CONGRESS 584-59 1979 COMPANELLA JACK MANAGER QUAL ADMIN FARMING REP CO NEW YORK NY 11735

36. **FOCUSING QUALITY COSTS USING THE BASICS**
ASQC 40TH ANNUAL QUALITY CONGRESS 401-40 1986 WINCHELL WILLIAM O GENERAL MOTORS CORPORATION WARREN MI 48090

37. **FRONT LINE COSTS ADMINISTRATION**
1955 COOLING WILMER C CONOVER-MAST PUBLICATIONS INC

38. **GROUP TESTING AND THE EFFECTS OF COST RATIO**
ASQC 39TH ANNUAL QUALITY CONGRESS 563-56 1985 MUNDEL, P.E. AUGUST B CONSULTING ENGINEER WHITE PLAINS NY 10605

39. **GUIDE FOR MANAGING SUPPLIER QUALITY COSTS**
QUAL COSTS COMM AM SOC FOR QUAL CONT SECOND EDIT 1987 WINCHELL WILLIAM O

40. **GUIDE FOR MANAGING VENDOR QUALITY COSTS**
ASQC 35TH ANNUAL QUALITY CONGRESS 690-69 1981 WINCHELL W O MANAGER CUSTOMER SATIS ACT CONSUMER RELATIONS & SER STAFF DETROIT MI 48202

41. **GUIDE FOR MANAGING VENDOR QUALITY COSTS**
ASQC 34TH ANNUAL QUALITY CONGRESS 483-48 1980 WINCHELL W O MANAGER CUSTOMER SATISFACTION ACT WARREN MI 48090

42. **GUIDE FOR MANAGING VENDOR QUALITY COSTS**
ASQC 36TH ANNUAL QUALITY CONGRESS 367-37 1982 WINCHELL W O CONSUMER RELATIONS & SER STAFF GENERAL MOTORS CORPORATION DETROIT MI 48202

43. **GUIDE FOR REDUCING QUALITY COSTS**
ASQC 36TH ANNUAL QUALITY CONGRESS 360-36 1982 WILLIAMS RONALD J LEVITON MANUFACTURING CO, INC. LITTLE NECK NY

44. **GUIDE FOR REDUCING QUALITY COSTS**
ASQC 34TH ANNUAL QUALITY CONGRESS 56-59 1980 ZERFAS JAMES F MANAGER, QUALITY CONTROL JEFFEREY MINING MACHINERY DIV ARRINGTON LANCE PRESIDENT

45. **GUIDE FOR REDUCING QUALITY COSTS CAMPENELLA**
QUAL COST COMM AMER SOC FOR QUAL CONTROL 1987

46. **HANDBOOK FOR TOTAL QUALITY ASSURANCE**
1986 STILE EDWARD M BUREAU OF BUSINESS PRACTICE

47. **HANDBOOK FOR TOTAL QUALITY ASSURANCE**
LOC-64-2221 1986 STILES EDWARD M BUREAU OF BUSINESS PRACTICE

48. **HIDDEN FACTORY, THE**
HARVARD BUSINESS REVIEW 142-15 1985 MILLER JEFFREY G VOLLMANN THOMAS E

49. **HOW TO MAKE IT RIGHT THE FIRST TIME**
BUSINESS WEEK 142-14 1987 PORT OTIS

50. **HOW TO START A QUALITY COST PROGRAM - DON'T**
ASQC 33RD ANNUAL QUALITY CONGRESS 410 1979 BROWN F X STAFF ASSISTANT WESTINGHOUSE ELECTRIC CORP CHURCHILL BORO PV

51. **HUMAN RESOURCE TOOL FOR QUALITY IMPROVEMENT**
ASQC 39TH ANNUAL QUALITY CONGRESS 616-63 1985 BERGER, PH. D. JOHN A W.A. GOLOMSKI & ASSOCIATES CHICAGO IL 60605

52. **I KNOW IT WHEN I SEE IT**
1985 GUASPARI JOHN AMERICAN MANAGEMENT ASSOC NEW YORK NY

53. **IMPLEMENTING A QUALITY COST SYSTEM**
QUALITY PROGRESS 16-19 1972 RHODES R C

54. **IMPROVED PRODUCTIVITY THROUGH QUALTIY MGM'T**
ASQC 36TH ANNUAL QUALITY CONGRESS 491-50 1982 SCANLON FRANK THE HARTFORD INSURANCE GROUP ITT WLD HEADQUARTERS NY HAGAN JOHN T

55. **IN SEARCH OF EXCELLENCE**
HD70,U5P424 1982 PETUS THOMAS HARPER AND ROW PUBLISHERS WATERMAN, JR ROBERT H

56. **INCREASED PROFITS THROUGH COMPANY WIDE COMMITTMENT**
ASQC 39TH ANNUAL QUALITY CONGRESS 62-67 1985 ORTWEIN WILLIAM J UNITED TECHNOLOGIES CORP EAST HARTFORD CT 06108

57. **INNOVATIONS FOR QUALITY COSTS IN THE NEW DECADE**
ASQC 34TH ANNUAL QUALITY CONGRESS 546-55 1980 BREWER CLAYTON C GENERAL ELECTRIC CO

58. **INSURANCE FIRM SHOWS THAT QUALITY HAS VALUE**
QUALITY PROGRESS 41-45 1985 TOWNSEND PATRICK L

59. **INTEGRATED APPROACH TO QUALITY IMPROVEMENT, AN**
ASQC 39TH ANNUAL QUALITY CONGRESS 434-44 1985 SHILLINGS J W ALLEGHENY LUDLUM STEEL CORP BRACKENRIDGE PA 15014 DUNN D S WALL J Q

60. **INVESTING IN PREVENTIVE QUALITY COSTS**
QUALITY PROGRESS 12-17 1978 VEEN B

61. **IS QUALITY OUT OF CONTROL**
REPRINTS OF SPECIFIC ARTICLES 8.024 1984 VENSON WILLIAM D HOWARD BUSINESS REVIEW HEANY DONALD F

62. **JAPENESE MANUFACTURING TECHNIQUES**
1982 SCHONBERGER RICHARD J THE FREEPUSS A DIVISION

63. **JIT, A TEAM WORK APPROACH TO QUALITY IMPROVEMENT**
ASQC 39TH ANNUAL QUALITY CONGRESS 342-34 1985 GOETZ VICTOR J WARNER - LAMBERT COMPANY MORRIS PLAINS NJ 07950

64. **MANAGEMENT OF QUALITY ASSURANCE, THE**
TS156.6 S48 1985 SINKA MADHAU N JOHN WILERY & SONS WILLBORN WALTER W

65. **MANAGEMENT ROLE FOR QUALITY CONTROL, A**
HAGON H T AMERICAN MGMT ASSO

66. **MANAGING COST OF QUALITY**
ASQC 37TH ANNUAL QUALITY CONGRESS 463-46 1983 MURTHY VYASARAJ V HONEYWELL INFORMATION SYS, INC BILLERICA MA 01821

67. **MANAGING FOR RESULTS**
DDC CATALOGUE CARD 64-12670 1964 DRUCKER LETER F HARPER & ROW PUBLISHERS

68. **MANAGING FOR SUCCESS THROUGH THE QUALITY SYSTEM**
ASQC 38TH ANNUAL QUALITY CONGRESS 10-21 1984 CAPLAN FRANK V.P. CORP QUAL SYSTEMS GULL, INC. SMITHTOWN NY 11787

69. **MANAGING FOR SUCCESS THROUGH THE QUALITY SYSTEM**
29-58 1985 CAPLAN FRAK QUALITY PROGRESS

70. **MANAGING QUALITY FOR HIGHER PROFITS**
1982 BROH ROBERT A MCGRAW-HILL BOOK COMPANY

71. **MANAGING THE QUALITY FUNCTION**
1987 PEACH ROBERT W THE MANAGEMENT INSTITUE

72. **MANAGING TO ACHIEVE QUALITY AND RELIABILITY**
1971 NIXON FRANK MCGRAW-HILL

73. **MANUFACTURING COST ENGINEERING HANDBOOK**
UNIVERSITY AMES, IOWA 1984 MALMSTROM ERIC DEPARTMENT OF INDUSTRIAL ENG IOWA STATE

74. **MARKETING RESEARCH & PRODUCT QUALITY**
ASQC 37TH ANNUAL QUALITY CONGRESS 385-39 1983 GRYNA, JR. FRANK M JURAN INSTITUE, INC. NEW YORK NY

75. **MEASUREMENT ERROR AND QUALITY COST**
ASQC 39TH ANNUAL QUALITY CONGRESS 504-51 1985 BHUYAN SAMAR K MIDDLETOWN NJ 07748

77. **MEASURING QUALITY COSTS BY WORK SAMPLING**
ASQC 36TH ANNUAL QUALITY CONGRESS 138-14 1982 ESTERBY JAMES L DIRECTOR QUALITY ASSURANCE VICTOR EQUIPMENT COMPANY DENTON TX 76201

77. **METHOD FOR PREDICTING WARRANTY COSTS, A**
ASQC 32ND ANNUAL QUALITY CONGRESS 205-21 1978 GRIMM ANDREW F MANAGER, QUALITY ASSURANCE CLARK EQUIPMENT CO. BUCHANAN MI

78. **MIL-Q-9858A**
3.3

79. **MIL-STD-1520B**
4.11-1

80. **MIL-STD-1520C**
5.7

81. **MINIMIZED COST SAMPLING TECHNIQUE**
ASQC 35TH ANNUAL QUALITY CONGRESS 958-96 1981 LEE DENNIS D SENIOR RELIABILITY ENGINEER SUNDSTRAND HYDRO-TRANSMISSION AMES IW 50010

82. **MINIMIZING QUALITY COSTS THROUGH EFFECTIVE DESIGN**
ASQC 40TH ANNUAL QUALITY CONGRESS 411-41 1986 MAYHEW EMILY A QUALITY PPOGRAMS SPECIALIST BABCOCK & WILCOX LYNCHBURG VA 24506 0935

83. **MINIMIZING THE COST OF INSPECTION**
ASQC 36TH ANNUAL QUALITY CONGRESS 485-49 1982 LATZKO WILLIAM J IRVING TRUST COMPANY NEW YORK NY

84. **MR. CEO, YOUR COMPANIES QUALITY POSTURE TS SLOWING**
ASQC 36TH ANNUAL QUALITY CONGRESS 866-87 1982 DOBBINS RICHARD K PRINCIPAL SYSTEMS ENGINEER HONEYWELL INC. FORT WASHINGTON PA 19034

85. **MRP, KANBAN AND OPT**
INVENTORIES & PRODUCTION MAGAZINE 1982 ROX ROBERT E

86. **ON THE ROAD TO QUALITY SAVINGS**
ASQC 39TH ANNUAL QUALITY CONGRESS 47-52 1985 GOELLER WILLIAM D LTV AEROSPACE & DEFENSE CO. DALLAS TX 75265

87. **OVERCOMING REGULATORY CONSTRAINTS IN QUALITY COSTS**
ASQC 36TH ANNUAL QUALITY CONGRESS 8-12 1982 SZYMANSKI EARL T CORPORATE QUALITY ASSURANCE ABBOTT LABORATORIES NORTH CHICAGO IL 60064

88. **PARTICIPATING APPROACH TO QUALITY, A**
ASQC 36TH ANNUAL QUALITY CONGRESS 373-37 1982 GUNNESON DR. ALVIN O V.P. & DIR- QUAL WORLDWIDE REVLON, INC. EDISON NJ

89. **PHILOSOPHY AND USEFULNESS OF QUALITY COST, THE**
ASQC 32ND ANNUAL QUALITY CONGRESS 644-64 1978 MOORE WILLIAM N MANAGER MANUFACTURING OPER WESTINGHOUSE ELECTRIC CORP SYKESVILLE MD 21784

90. **POOR - QUALITY COST**
ASQC QUALITY PRESS 1987 HARRINGTON JAMES H

91. **POOR QUALITY COST**
ASQC QUALITY PRESS T5156 H346 1987 HARRINGTON H D

92. **PREDICTING QUALITY COST CHANGES USING REGRESSION**
ASQC 40TH ANNUAL QUALITY CONGRESS 405-41 1986 KRISHNAMOORTHI K S INDUSTRIAL ENGINEERING BRADLEY UNIVERSITY PEORIA IL

93. **PRINCIPLES OF QUALITY COSTS**
ASQC 36TH ANNUAL QUALITY CONGRESS 124-13 1982 CAMPANELLA JACK FAIRCHILD REPUBLIC COMPANY FARMINGDALE NY

94. **PRINCIPLES OF QUALITY COSTS**
QUALITY COSTS COMMITTEE 1986 HAGAN JOHN T AMERICAN SOCIETY FOR QUAL CONT

95. **PROCESS CONTROL MANAGEMENT**
ASQC 38TH ANNUAL QUALITY CONGRESS 198-20 1984 DENISSOFF BASILE A CORNING GLASS WORKS RALEIGH NC 27604

96. **PROFIT - THE RESULT OF QUALITY**
ASQC 39TH ANNUAL QUALITY CONGRESS 422-42 1985 SWATON LAWRENCE E ABBOTT LABORATORIES IRVING TX 75061

97. **PROFIT IMPROVEMENT THROUGH SCRAP REDUCTION**
ASQC 38TH ANNUAL QUALITY CONGRESS 289-29 1984 REAMES J P CORPORATE MANA - QUAL ASSUR ALLIED CORPORATION MORRISTOWN NJ 07960

98. **PROJECT COST CONTROL FOR MANAGERS**
1985 TOMPKINS BILL G GULF PUBLISHING COMPANY HOUSTON TX

99. **Q COST/RESULTS - THE PETROLENM INDUSTRY**
ASQC 36TH ANNUAL QUALITY CONGRESS 873-87 1982 BREWER CLYDE W OTIS ENGINEERING CORP. DALLAS TX

100. **QA CONNECTION: KEY TO EXCELLENCE THRU IMPROVEMENT!**
ASQC 40TH ANNUAL QUALITY CONGRESS 718-72 1986 DOBBINS RICHARD K HONEYWELL INC. FORT WASHINGTON PA 19034

101. **QA SYSTEM CAN IMPROVE PROFITS, THE**
ASQC 35TH ANNUAL QUALITY CONGRESS 915-92 1981 CASWELL A R ABBOTT LABORATORIES LTD NORTH CHICAGO IL

102. **QUALITY**
SPECIAL REPORT BUSINESS WEEK 142-14 1987

103. **QUALITY & OR - QUALITY COSTS EQUALS PRODUCTIVITY**
ASQC 37TH ANNUAL QUALITY CONGRESS 121-12 1983 AUBREY, II CHARLES A MANAGER, QUALITY ASSURANCE CONTINENTAL ILLINOIS NATIONAL CHICAGO IL 60693

104. **QUALITY AND FINANCE**
QUALITY 42 1987 BOUILLON, II LINCOLN

105. **QUALITY CONTROL**
HEAR-TSK FORCE ON SELE DEF PROC MAT COMM ON ARM 1985

106. **QUALITY CONTROL**
PRENTICE-HALL SECOND EDITION 1986 BESTERFIELD DALE H

107. **QUALITY CONTROL FOR PROFIT**
1977 LESTER RONALD H INDUSTRIAL PRESS INC
ENRICK NORBERT L PH.D MOTTLEY, JR HARRY E

108. **QUALITY CONTROL HANDBOOK**
THIRD EDITION 1979 JURAN J M MCGRAW-HILL BOOK COMPANY

109. **QUALITY CONTROL HANDBOOK**
T5156.Q3T8 1984 JURAN J M MCGRAW-HILL
TUNDUALL D M

110. **QUALITY CONTROL IN A SERVICE BUSINESS**
1975 HOSTAGE GM HOWARD BUSINESS REVIEW

111. **QUALITY CONTROL MEETING THE NEW COMPETITION**
BERGER ROGER W EDUCATION FOR MANAGEMENT INC.

112. **QUALITY COST & SCHEDULE SAVINGS FROM SURVEILLANCE**
ASQC 38TH ANNUAL QUALITY CONGRESS 41-45 1984 HARDEE GEORGE E
DIXON LLOYD M BIRMINGHAM FLETCHER A

113. **QUALITY COST - THE WHOLE AND ITS PARTS**
QUALITY 18-20 1976 HARRINGTON JAMES H

114. **QUALITY COST -- A KEY TO PRODUCTIVITY**
ASQC 35TH ANNUAL QUALITY CONGRESS 420-43 1981 HARRINGTON H J
INTERNATIONAL BUS MACH CORP SAN JOSE CA

114. **QUALITY COST ANALYSIS**
ASQC 35TH ANNUAL QUALITY CONGRESS 432-43 1981 ESTERBY JAMES L DIRECTOR QUALITY ASSURANCE VICTOR EQUIPMENT COMPANY DAYTON TX 76201

116. **QUALITY COST AND ECONOMIC ANALYSIS**
17-29 1981 BERGER ROGER W AMERICAN MANAGEMENT ASSO

117. **QUALITY COST AND PROFIT PERFORMANCE**
ASQC 32ND ANNUAL QUALITY CONGRESS 505-51 1978 BROWN FRANCIS X STAFF ASSISTANT WESTINGHOUSE ELECTRIC CORP PITTSBURGH PV 15235 KANE ROGER W STAFF ASSISTANT

118. **QUALITY COST BREAKTHROUGHTS IN U.S. PRODUCTION**
ASQC 37TH ANNUAL QUALITY CONGRESS 202-20 1983 MUNDEL AUGUST B AUGUST B. MUNDEL ASSOCIATES WHITE PLAINS NY 10605

119. **QUALITY COST II: THE ECONOMICS OF QUALITY IMPROVEMENT**
QUALITY PROGRESS 48-51 1985 HAGAN JOHN T

120. **QUALITY COST PRINCIPLES A PREVIEW**
ASQC 34TH ANNUAL QUALITY CONGRESS 542-54 1980 CORCORAN FRANK J QA SPECIALIST TRAIN & MGMT SER LITTLE FALLS NJ 07424

121. **QUALITY COSTS**
IDEAS AND APP A COLL OF PAP AM SOC FOR QUAL CONT 1982

122. **QUALITY COSTS - A NEW PERSPECTIVE**
ASQC 33RD ANNUAL QUALITY CONGRESS 575-58 1979 KROEGER ROBERT C MANAGER RELIABILITY & QUAL ASS GENERAL ELECTRIC COMPANY AESD UTICA NY 12503

123. **QUALITY COSTS - A REVIEW AND PREVIEW**
ASQC 34TH ANNUAL QUALITY CONGRESS 538-54 1980 BREWER CLYDE W DIRECTOR-QUALITY OTIS ENGINEERING CORPORATION

124. **QUALITY COSTS - WHAT DOES MANAGEMENT EXPECT?**
ASQC 32ND ANNUAL QUALITY CONGRESS 608-61 1978 GRYNA, JR DR. FRANK M PROF OF INDUSTRIAL ENGINEERING BRADLEY UNIVERSITY PEORIA IL 61625

AD-A206 935 COST OF QUALITY EVALUATION METHODOLOGIES HANDBOOK(U) 3/3
WALLACE AND CO FAIRBORN OH W J GRUNEWALD ET AL.
28 JUL 88 F33657-86-D-0094

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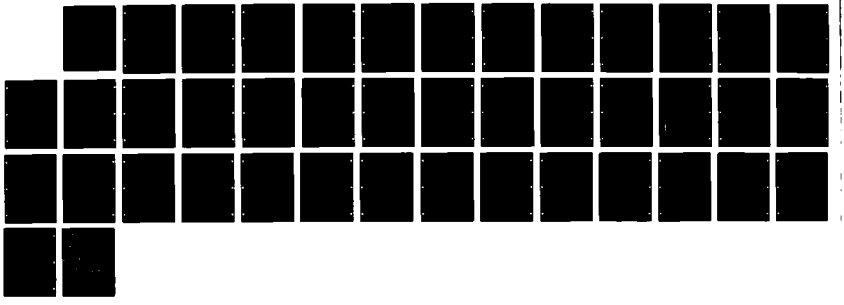

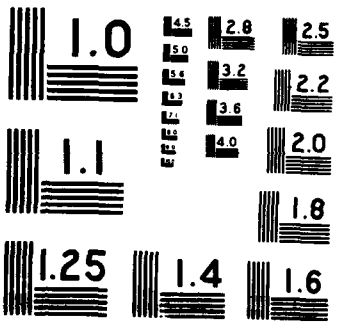
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125. QUALITY 70-71 1979 ALFORD REX E

126. QUALITY COSTS - WHERE TO START PART III
QUALITY 40-42 1979 ALFORD REX E

127. QUALITY COSTS - WHERE TO START, PART 1
QUALITY 36-37 1979 ALFORD REX E

128. QUALITY COSTS CAN BE SOLD: PART II
ASQC 35TH ANNUAL QUALITY CONGRESS 737-74 1981 BREEZE JOHN D MANAGER QUALITY ASSURANCE HERMES ELECTRONICS LIMITED FARRELL J R GENERAL MANAGER

129. QUALITY COSTS II -THE ECONOMICS OF QUALITY IMPROVEMENT
ASQC 39TH ANNUAL QUALITY CONGRESS 53 1985 HAGEN JOHN T ITT CORP. NEW YORK NY 10022

130. QUALITY COSTS IN A NON-MANUFACTURING ENVIROMENT
ASQC 37TH ANNUAL QUALITY CONGRESS 296-30 1983 SCANLON FRANK SECRETARY DIR OF ED/QUAL THE HARTFORD INSURANCE GROUP HARTFORD CT 06115

131. QUALITY COSTS IN THE PROCESS INDUSTRIES
ASQC 37TH ANNUAL QUALITY CONGRESS 207-21 1983 SIFF WALTER JAMES RIVER GRAPHICS SOUTH HADLEY MA 01075

132. QUALITY COSTS- PAY
ASQC 36TH ANNUAL QUALITY CONGRESS 860-86 1982 DEMETRIOUS JAMES MANAGER OF QUALITY ADMIN ITT AVIONICS DIVISION CLIFTON NJ

133. QUALITY COSTS: IDEAS AND APPLICATIONS A COLLECTION OF PAPERS
AMERICAN SPEC QUAL CONT INC. 1984 VARIOUS

134. QUALITY COSTS: WE KNOW WHERE WE'RE GOING! DO YOU?
ASQC 37TH ANNUAL QUALITY CONGRESS 457-46 1983 WAYNE JAMES J MANAGER, ACCOUNTING HARNISCHFEGER CORPORATION ESCANABA MI GRIMM ANDRES F MANAGER, QUALITY CONTROL

135. QUALITY IMPROVEMENT AND LEARNING IN PRODUCTIVE SYSTEMS
MANAGEMENT SCIENCE VOL 32 NO 10 1301-1 1986 FINE CHARLES H

136. **QUALITY IMPROVEMENT IN A MARKETING ORGANIZATION**
46-51 1985 WARREN NICKELL L QUALITY PROGRESS

137. **QUALITY IS FREE**
1979 CROSBY PHILLIP B MCGRAW-HILL BOOK COMPANY

138. **QUALITY IS FREE**
TS156.6C76 CROSBY PHILLIP B MCGRAW-HILL

139. **QUALITY IS MORE THAN MAKING A PRODUCT**
139-14 1983 TAKEUCH HORIOTAKA HARVARD BUSINESS REVIEW QUELCH JOHN H

140. **QUALITY MANAGEMENT THROUGH QUALITY INDICATORS: A NEW APPROACH**
ASQC 33RD ANNUAL QUALITY CONGRESS 710-71 1979 PURI SUBHASH C CHIEF STATISTICIAN FOOD PROD & MARKETING BRANCH

141. **QUALITY MANAGER'S JOB OPTIMIZE COSTS, THE**
ASQC 37TH ANNUAL QUALITY CONGRESS 301-30 1983 NOZ JR. WILLIAM C PRINCIPAL ENGINEER POLAROID CORP CAMBRIDGE MA 02139 REDDING BRADLEY F QUALITY MANAGER WARE PAUL A SENIOR ENGINEER

142. **QUALITY MEASUREMENT FOR PERSONNEL SERVICES***
ASQC 34TH ANNUAL QUALITY CONGRESS 262-26 1980 HERSHAUER JAMES C PROFESSOR OF QUANTATIVE SYST ARIZONA STATE UNIVERSITY TEMPE AZ

143. **QUALITY ON THE LINE**
65-75 1983 GARVIN DAVID A HARVARD BUSINESS REVIEW

144. **QUALITY OPTIMINZATION VIA TOTAL QUALITY COSTS**
ASQC 35TH ANNUAL QUALITY CONGRESS 729-73 1981 ZALUDOVA A H NAT RES INST FOR MACH DES PRA ZALUD F H AUTO RES INST PRAG CZECH

145. **QUALITY POSTURE - A PROFIT/SURVIVAL CHALLENGE, YOUR**
ASQC 35TH ANNUAL QUALITY CONGRESS 485-49 1981 DUBBINS RICHARD K PRINCIPAL SYSTEMS ENGINEER HONEYWELL INC. FORT WASHINGTON PA 19034

146. **QUALITY PRESENTATION**
WALLACE AND COMPANY

147. **QUALITY PROGRAM MODELING FOR COST EFFECTIVE TAILORING**
ASQC 34TH ANNUAL QUALITY CONGRESS 648-65 1980 WILHELM W C MANAGER QUALITY ASSURANCE SYSTEMS POMONA CA

148. **QUALITY REPUTATION - A PRECIOUS ASSET**
ASQC 34TH ANNUAL QUALITY CONGRESS 145-15 1980 UTZIG LAWRENCE J CONSULTANT - PRODUCT QUALITY GENERAL ELECTRIC COMPANY FAIRFIELD CT 06431

149. **QUALITY VS BUSINESS WHICH MANAGEMENT COMMITMENT**
ASQC 37TH ANNUAL QUALITY CONGRESS 381-38 1983 DOBBINS RICHARD K PRINCIPAL SYSTEMS ENGINEER HONEYWELL INC FORT WASHINGTON PA 19034

150. **QUALITY WITHOUT TEARS**
1984 CROSBY PHILLIP B MCGRAW-HILL BOOK COMPANY

151. **QUALITY/RELIABILITY CHALLENGES FOR THE 1980'S**
ASQC 34TH ANNUAL QUALITY CONGRESS 662-66 1980 GURANATHA T P. ENG XEROX CORP

152. **QUEST FOR QUALITY**
HALE ROGER L HOELSCHER DOUGLAS R ROWAL RONALD E

153. **RECENT ADVANCES IN STRESS SCREENING**
ASQC 40TH ANNUAL QUALITY CONGRESS 516-53 1986 HOBBS GREGG K PH.D. HOBBS ENGINEERING CORPORATION LAGUNA HILLS CA 92653

154. **REDUCING APPRAISAL COSTS**
ASQC 32ND ANNUAL QUALITY CONGRESS 650-65 1978 DAWES EDGER W CORP QUAL ASSUR MANAGER VEEDER - ROOT CO. HARTFORD CT 06102

155. **REDUCING FAILURE COST AND MEASURING IMPROVEMENT**
ASQC 37TH ANNUAL QUALITY CONGRESS 454-45 1983 WINCHELL WILLIAM O ADMINISTRATOR SERVICE SECTION GENERAL MOTORS CORPORATION DETROIT MI 48202

156. **RELATIONSHIP OF FINANCIAL INFORMATION & QUALITY COSTS, A TUTORIAL**
ASQC 39TH ANNUAL QUALITY CONGRESS 193-20 1985 SZYMANSKI EARL T ABBOTT LABORATORIES NORTH CHICAGO IL 60064

157. **SAMPLING PLANS USING COST RATIOS AND LOT HISTORY**
ASQC 38TH ANNUAL QUALITY CONGRESS 202-20 1984 KEATS BERT J ASSOCIATE PROFESSOR DEPART OF INDUST AND MANAG TEMPE AZ 85287 CASE KENNETH E PROFESSOR, OKLA STATE UNIV

158. **SELECTION OF MIL-STD-105D PLANS BASED ON COSTS**
ASQC 35TH ANNUAL QUALITY CONGRESS 475-48 1981 LIEBESMAN DR. BURTON S BELL TELEPHONE LABORATORIES HOLMDEL NJ 07733

159. **SOCIAL QUALITY & REGULATORY COSTS**
ASQC 34TH ANNUAL QUALITY CONGRESS 656-66 1980 SCHOCK, JR HARVEY E PRODUCT ASSURANCE CONSULTING HADDONFIELD NJ 08033

160. **SOLVING THE QUALITY COST EQUATION**
ASQC 40TH ANNUAL QUALITY CONGRESS 714-71 1986 KILDAHL DAVID D QUALITY ASSURANCE ENGINEER HONEYWELL INCORPORATED MINNEAPOLIS MN 55440

161. **STRATEGIC PLANNING OF QUALITY AND ITS ASSURANCE**
ASQC 35TH ANNUAL QUALITY CONGRESS 491-49 1981 ZELLER HERMAN J SIEMENS A.G. MUNTCH

162. **STUDY COSTS & IMPROVE PRODUCTIVITY**
ASQC 36TH ANNUAL QUALITY CONGRESS 876-88 1982 ORTWEIN WILLIAM J PRATT & WHITNEY AIRCRAFT EAST HARTFORD CT

163. **SUPPLIERS QUALITY ASSURANCE PROGRAM REQUIREMENTS**
MIL-STD-1535A

164. **TECHNIQUES USED FOR QUALITY COST CONTROL**
WALLACE AND COMPANY

165. **TEST COST AVOIDANCE PROGRAM THAT WORKS, A**
ASQC 38TH ANNUAL QUALITY CONGRESS 77-81 1984 DUHAN DANIEL M

166. **THE SNOWBALL EFFECT OF DATA GATHERING**
ASQC 35TH ANNUAL QUALITY CONGRESS 937-94 1981 JOHNSON BRUCE DIRECTOR QUALITY ASSURANCE MSI DATA CORPORATION COSTA MESA CA

167. **THE SUPERMANAGERS**
HD31.H445 1984 HILLER ROBERT TRUMANS TALLY BOOKS

168. **THEORY WHY**
1986 GUSPARI JOHN AMERICAN MANAGEMENT ASSOC NEW YORK NY

169. **TOTAL QUALITY CONTROL**
THIRD EDITION 1983 FEIGENBAUM A V MCGRAW-HILL BOOK COMPANY

170. **TOTAL QUALITY CONTROL**
TS156F44 1983 FEIGENBAUM A V MCGRAW-HILL BOOK CO

171. **TUTORIAL ON QUALITY COSTS-WHAT & HOW**
ASQC 34TH ANNUAL QUALITY CONGRESS 376 1980 WILLIAMS RONALD J QUALITY ASSURANCE TECHNICIAN AUTOMATIC SWITCH COMPANY

172. **USING QUALITY COST ANALYSIS FOR MANAGEMENT IMPROVEMENT**
INDUSTRIAL ENGINEERING 46-50 1987 BLANK LEE P.E. SOLARZANO JORGE

173. **USING QUALITY COSTS IN PRODUCTIVITY MEASUREMENT**
ASQC 37TH ANNUAL QUALITY CONGRESS 211-21 1983 SINK SCOTT D PH.D. PE SCHOOL OF INDUSTRIAL ENG STILLWATER OK 74078 KEATS JOHN B PH.D. PE ASSOC PRO ASSIST PRO

174. **VERIFYING DESIGN QUALITY**
ASQC 38TH ANNUAL QUALITY CONGRESS 176-18 1984 BURGEES JOHN A WESTINGHOUSE ELECTRIC CORP MUNCIE IN 47302

175. **WAST-COME OUT, COME OUT WHEREVER YOUR ARE**
5-8 1987 BODEK NORMAN PUBLISHER PROCTIVITY INC

176. **WHY QC NEED PR**
INDUSTRY WEEK 37-39 1978 SMITH MARTIN R

177. **YOUR COST ACCOUNTING UP TO DATE, IS**
HARVARD BUSINESS REVIEW 133-13 1982 EILER ROBERT G
GLETZ WALTER K KEAGAN DANIEL

178. **ZERO DEFECTS**
1966 HALPIN J F MCGRAW-HILL

APPENDIX A
EXAMPLES OF TYPICAL COSTS OF QUALITY

Prevention:
- Quality engineering
- Quality circles
- Quality training
- Supervision of prevention activities
- Pilot studies
- Systems development
- Process controls
- Technical support provided to vendors
- Analysis of in-house processes for the purpose of improving quality
- Auditing the effectiveness of the quality system

Appraisal:
- Supplies used in test and inspection
- Test and inspection of incoming materials
- Component inspection and testing
- Review of sales orders for accuracy
- In-process inspection
- Final product inspection and testing
- Field inspection at customer site prior to final release of product
- Reliability testing
- Supervision of appraisal activities
- Plant utilities in inspection area
- Depreciation of test equipment
- Internal audits of inventory

Internal Failure:
- Net cost of scrap
- Net cost of spoilage
- Disposal of defective product
- Rework labor and overhead
- Reinspection of reworked product
- Retest of reworked product
- Downtime due to quality problems
- Net opportunity cost of products classified as seconds
- Data re-entered due to keypunch errors
- Defect cause analysis and investigation
- Revision of in-house computer programs due to software errors
- Adjusting entries necessitated by quality problems

External Failure:
- Cost of responding to customer complaints
- Investigation of customer claims on warranty
- Warranty repairs and replacements
- Out-of-warranty repairs and replacements
- Product recalls
- Product liability
- Returns and allowances because of quality problems
- Opportunity cost of lost sales because of bad quality reputation

A. APPRAISAL COSTS

1. Production equipment qualification and recertification

2. Evaluation and audit of entire quality assurance program

3. Quality inference data analysis

4. Process control data analysis

5. Final test at customer's site; can be divided or categorized as salaries, equipment not capitalized, rental charges for equipment, supplies, travel expense, and subsistence

6. Final test in plant by sampling techniques; can be divided or categorized as wages, equipment not capitalized, rental of equipment, and supplies

7. Final inspection in plant by sampling techniques; can be divided or categorized as wages, equipment not capitalized, rental of equipment, and supplies

8. Portion of 100% final test chargeable to quality inference

9. Portion of 100% final inspection chargeable to quality inference

10. Outside laboratories charges for tests on finished goods

11. Portion of 100% laboratory final test chargeable to quality inference

12. Inspection and release of finished prototypes or first finished units

13. Test of finished prototypes or first finished units

14. Incoming test by sampling techniques; can be divided or categorized into wages, equipment not capitalized, rental of equipment, and supplies

15. Incoming inspection by sampling techniques; can be divided or categorized into wages, equipment not capitalized, rental of equipment and supplies

16. Portion of 100% incoming inspection chargeable to quality inference

17. Portion of 100% incoming test chargeable to quality inference

18. Outside laboratories charges for tests on incoming material

19. Vendors charges for tests on incoming material

20. Laboratory test of incoming materials by sampling techniques; can be divided or categorized into wages, equipment not capitalized rental of equipment, and supplies

21. Portion of 100% laboratory test of incoming materials chargeable to quality inference

22. First piece inspection; can be divided or categorized into wages, equipment not capitalized rental for equipment, and supplies

23. First piece test; can be divided or categorized into wages, equipment not capitalized, rental for equipment, and supplies

24. In-process inspection by sampling procedures; can be divided or categorized into wages, equipment not capitalized, rental for equipment, and supplies

25. In-process test by sampling procedures; can be divided or categorized into wages, equipment, and supplies

26. Portion of 100% in-process inspection chargeable to quality inference

28. Portion of 100% laboratory in-process test chargeable to quality inference

29. Outside laboratories charges for tests on in-process material

30. Process control tests; can be broken into wages, equipment not capitalized, rental for equipment, and supplies

31. Cost of product destroyed in testing; can be divided into incoming, in-process, first piece, and process control

32. Auditing systems and procedures

33. Auditing product quality

34. Auditing process control and process control tests

35. Audit of product packing

36. Audit activities to evaluate end product quality and reliability; including auditing systems, procedures, calculations and performance

37. Surveillance of special operations and processes

38. Vendor quality surveillance

39. Inspection supplies

40. Test supplies

41. Tests for evaluating end product quality and reliability, includes life, environment and reliability tests

42. Set-up for test

43. Set-up for inspection

44. Test of product packing

45. Inspection of product packing

46. Quality checking operations by production employees

47. Inspection and test activity to review templates and tools

48. Reinspection of jigs and fixtures

49. Requalification tests of tools and processes

50. Inspection and test activity to give data on effectiveness of corrective actions

51. Reports of inspections

52. Reports of tests

53. Data processing, filing, and summarizing

B. INTERNAL FAILURE

1. Failure analysis including cause of scrap and cause of rework; can be further divided or categorized as wages, rental of equipment, equipment not capitalized, supplies, and vendor contacts

2. Failure analysis of purchased parts including investigation of cause of scrap and cause of rework; can be segregated into wages, equipment not capitalized, rental charges for equipment, supplies, travel costs, and vendor contacts

3. Failure analysis consisting of special tests and inspections

4. Portion of 100% final test due to need to eliminate defective product

5. Portions of 100% final inspection due to need to eliminate defective product

6. Portion of 100% laboratory final test chargeable to need to eliminate defective product

7. Portion of 100% incoming test chargeable to need to eliminate defective product

8. Portion of 100% incoming inspection chargeable to need to eliminate defective product

9. Portion of 100% laboratory test of incoming materials chargeable to need to eliminate defective product

10. Portion of 100% in-process test chargeable to need to eliminate defective product

11. Portion of 100% in-process inspection chargeable to need to eliminate defective product

12. Portion of 100% laboratory in-process test chargeable to need to eliminate defective product

13. Material Review Board activities either formal or informal; may be subdivided into disposition is scrap, disposition is rework, disposition is downgraded material

14. Rework (includes failure correction in defective product); may be divided into (a) produced internally and (b) purchase material; (a) may be then divided into inspection and test error or production error; (b) may be divided into ordered incorrectly or defective

15. Evaluation of reworked material inspection and test data

16. Inspection of reworked material

17. Test of reworked material

18. Rework fault of vendor

19. Scrap; production error; may be divided into produced internally or purchased material

20. Scrap; test or inspection error; may be divided into produced internally or purchased material

21. Scrap; material in stock or received before effective cancellation which failure analysis shows to be inadequate

22. Charges for canceling orders when defect analysis shows material to be inadequate

23. Scrap; fault of vendor

24. Downgrading; loss in value of product due to not meeting planned requirements but still has more than salvage value

25. Downtime; loss in production time due to failure analysis or defective product

26. Reinspection due to product defects (not after rework)

27. Re-test due to product defects (not after rework)

28. Extra production operations added because of presence of defectives

29. Extra inspections due to product defects (not 100% screening)

30. Extra tests due to product defects (not 100% screening)

31. Incidental costs of scrap

32. Incidental costs of rework

33. Replacement of lost material

34. Replacement of material damaged between departments

35. Rejection report writing and processing

36. Extra record keeping due to defective products

37. Burden arising from excess production capacity necessitated by defectives 38. Vendor charges for corrective engineering for process

39. Corrective engineering for processes - not analysis

40. Retooling because of corrective engineering

41. Rework of patterns, molds, or jigs due to low quality

42. Redesign of patterns, molds, or jigs due to low quality

43. Refabrication of patterns, molds, or jigs due to low quality

44. Defect inference data analysis (failure analysis data analysis)

C. EXTERNAL FAILURE

1. Field failure analysis for purpose of taking corrective action for future production

2. Field complaint investigation for purposes of taking voluntary corrective action on equipment now in customers' use; may be divided into wages, travel expense, subsistence, equipment, and supplies

3. Field complaint investigation for purpose of in-guarantee corrections; may be divided into travel, subsistence, wages, equipment, and supplies

4. Field complaint negotiations with customers

5. Field repair performed voluntarily to prevent future customer complaints

6. Field service performed voluntarily to prevent future customer complaints

7. Engineering for in-plant correction of field complaint because of expressed or implied guarantees

8. Engineering for field correction of field complaint because of expressed or implied guarantees

9. Repairs for in-plant correction of field complaint because of expressed or implied guarantees

10. Repairs for field correction of field complaint because of expressed or implied guarantees

11. Production for in-plant correction of field complaint because of expressed or implied guarantees

12. Production for field correction of field complaint because of expressed or implied guarantees

13. Service for in-plant correction of field complaint because of expressed or implied guarantees

14. Service for field correction of field complaint because of expressed or implied guarantees

15. Billing adjustment or allowance because of expressed or implied guarantees

16. Loss of quality or reliability incentive fees

17. Loss of customer good will

18. Business policy concessions to customer (not part of quality related costs) 19. Vendor charges for corrective engineering for product

20. Corrective engineering for product - not failure analysis (possibility caused by quality or reliability failure analysis)

21. Vendor charges for failure analysis

D. PREVENTION

1. Vendor charges for quality engineering in process planning
2. Vendor charges for quality engineering in product design
3. Quality engineering in designs for product including examinations of tolerances.
4. Quality engineering in new designs of processes
5. Planning control of vendor audits, surveillance and surveys
6. Travel costs for other quality purposed (not failure analysis)
7. Vendor contacts for quality purposes not failure analysis efforts
8. Verification and review of information supplied to vendor
9. Travel costs for vendor rating
10. Vendor contracts for vendor rating
11. Vendor rating; analysis of performance records
12. Vendor rating; keeping performance records
13. Vendor rating; evaluating quality capabilities
14. Vendor rating; evaluating reliability capabilities
15. Planning incoming test
16. Planning incoming inspection
17. Formulation and issuance of test procedures
18. Formulation and issuance of inspection procedures
19. Implementing test and inspection procedures
20. Purchase of test or material for devices (not capitalized) including procurement planning
21. Purchase of inspection devices or material for devices (not capitalized) including procurement planning
22. Construction of test devices (not capitalized)

23. Construction of inspection devices (not capitalized)

24. Design and development of test devices (not capitalized)

25. Design of inspection devices (not capitalized)

26. Design of measurement devices (not capitalized)

27. Design and development of control devices (not capitalized)

28. Rental or use charges for others' inspection equipment

29. Rental or use charges for others' test equipment

30. Depreciation write-off for capitalized inspection and test equipment (may be different from tax write off)

31. Formulation, issuance, and implementation of process controls

32. Development of process controls

33. Review of product packing

34. Training and education of inspection employees for quality

35. Training and education of test employees for quality

36. Training and education of special process evaluation employees for quality

37. Planning quality training and education

38. Conducting quality training and education

39. Employee certification and training for training for certification and recertification (does not include instruction for achievement of normal proficiency)

40. Training and education of production employees for quality

41. Reliability engineering benefiting quality

42. Other reliability activities benefiting quality

43. Quality review of tool design

44. Tool use coordination

45. Customer contacts for quality purposes not failure analysis efforts

46. Evaluation of customer quality requirements and existing plant capabilities

47. Formulation, issuance, and implementation of quality plans

48. Formulation and interpretation of quality standards

49. Formulation and coordination of specifications

50. Prescribing and recording policies and procedures for quality assurance

51. Planning and performing process capability experiments

52. Analysis of pre-production run data

53. Analysis of quality inference data prior to product shipment

54. Evaluation and analysis of entire quality cost data

55. Maintenance of test equipment

56. Maintenance of inspection equipment

57. Calibration of test equipment

58. Calibration of inspection equipment

59. Calibration of production equipment

60. Maintaining primary standards

61. Calibration laboratory for gauges and measuring devices

62. Vendor audit

E. GENERAL COSTS

1. Planning quality cost analysis system

2. Administration costs; includes elements not logically a part of quality creation, quality inference, or defect inference

3. Accounting and data processing cost incurred in accumulating, analyzing and reporting quality and reliability data

4. Handling and records control of equipment in storage or in transport to calibration laboratory

5. Cost of power consumed in test, inspection, or quality assurance department

6. Value of floor space used primarily for inspection or test

7. Equipment depreciation; remaining book value at time of replacement of capitalized equipment

8. Approval by outside agencies such as Underwriters Laboratory fees, product endorsement fees, insurance underwriters, and outside test labs

9. Control of stores tools

10. Periodic inspection of stored tools

11. Quality and reliability studies for bid proposals

APPENDIX B
SURVEY RESULTS

INDUSTRY SURVEY QUESTIONNAIRE

(CONDUCTED VIA TELEPHONE)

1. Are you using any measures of cost of quality as a management tool at this time?

   Yes _____ or No _____

2. If yes, at what level? (who looks at/uses the data?)

   _____

3. If not, why not? Have you considered it, and then rejected it?

   _____

4. What are the measures you are looking at?

   _____

   _____

5. How is the data expressed?

   _____

6. How is the data captured?
   Through standard accounting system?
   Special system
   Any changes made to accounting system?
   What? _____

7. What are you doing as a result of having the data?
   Goals to reduce? _____
   Identifying problem areas? _____

8. What are you using to gage the meaning of your COQ measurement? (Standard for measurement)

9. How long have you been measuring COQ and using it as a management tool?

10. What caused you to start looking at COQ?
    Government _____
    Other _____

11. Based on your experience up to now, do you believe use of COQ will continue?

12. In order to make the handbook of maximum benefit to government and the contractor, what one thing would you recommend we include when developing the book?

wallace

RESULTS OF CONTRACTOR SURVEYS

USING COST OF QUALITY	YES 90% NO 10%*
WHO LOOKS AT COST OF QUALITY	TOP 83% MID 83% 1ST LVL 40%
HOW IS IT EXPRESSED	$ 68% % SALES 30% % DIRECT LABOR 49%
WHAT IS MEASURED	FAILURE 73% (SRR)
	APPRAISAL 38%
	PREVENTION 38%
	OTHER THAN QA DEPARTMENT 3%
HOW IS IT CAPTURED	NORMAL ACCOUNTING SYSTEM 68% OTHER 49%
HOW IS IT USED	GOALS 40% TRENDS 51% CAB 17% **
JUDGED MEANING	TRENDS 82% OTHER 18%
HOW LONG USING	1 YR. 15% 1-3 20% 3-10 38% 10+ 27%
WHY USING	GOVERNMENT INTEREST 74% OTHER 57%
WILL IT CONTINUE	YES 100% NO _____

* 4 CHOSE NOT TO RESPOND

**DID NOT SURVEY MIL-S-1520 COVERAGE

Telephone Survey

Generally speaking, those companies surveyed indicated that they were using cost of quality as a management tool. Four chose not to respond to our survey when called. Of the two companies not using it, reasons given were:

- Three chose not to respond to our survey when called.
- One had just recently established a quality department.
- One had tried it and had not found it to be useful.

Of those companies using cost of quality, 73% indicated that their primary focus is on internal failure costs, while 38% said that they also looked at appraisal and prevention costs. However, of that 38% (24 companies), only two were looking beyond the quality department for any costs, in this case at the engineering function. Two of the twenty four were following the general guidelines developed by the Aerospace Industrial Association and the America Society for Quality Control.

As for who looks at the data, 83% or 52 companies indicated that top and middle level managers reviewed the data in some form, but only 40% said that the data was used at the first line supervision level as an aid to getting at problems.

The survey revealed that 68% of the companies expressed the data in terms of some dollar amount. Thirty percent looked at the data as a percentage of sales, while 49% looked at the data as a percent of direct labor. Seven companies looked at the data in terms of actual direct hours expended, and one in terms of percentage of material.

In 68% of the companies, cost of quality data used was captured through the normal accounting system. Use of a system above and beyond the normal accounting system occurred in 49% of the companies (so in 49% both the normal and an additional system is used). Usually the additional system consisted of personal computers located in the quality department.

As for what use is made of the data, 40% said they had established goals for reduction. However, many felt goals were not a good idea, and the survey found that 51% were using trend analysis rather than goals. Fully 23% were also using Pareto analysis as a technique for making meaningful use of the data. Only 17% said that they specifically used the available cost of quality data as a tool for their corrective action board process (the survey did not determine what percent of the contractors surveyed had MIL-STD-1520 as a contractual requirement).

In terms of how long the companies had been using cost of quality as a management tool, the survey revealed:

1 year	15%
1 - 3 years	20%
3 - 10 years	38%
10 years +	27%

When asked what caused them to embrace cost of quality as a management tool, 74% said it was the government requirement, while 57% said it was a combination of both government and recognition of the good business sense to do it. Fully 100% said they will continue to use cost of quality as a management tool.

Company representatives were also asked to express their opinion regarding what the handbook should contain in terms of guidance, cautions, etc. The list below reflects their input. Note: It is divided or categorized by the "top ten" responses, followed by all other input. The number in parenthesis indicates the frequency of that response.

INDUSTRY COMMENTS ON WHAT TO INCLUDE IN HANDBOOK

TOP TEN

- Allow for implementation leeway - unique by company (17)
- Tie in with 9858 and 1520. (10)
- Does contractor have a system and is he pursuing improvement. (9)
- Do not attempt to compare companies or industries. (9)
- Define cost of quality. (9)
- Explain how to use the data, especially MRB and CAB. (5)
- Use trend analysis, long term, not short term. (4)
- Manage the basic information. (4)
- Stress multi-disciplined approach early on. (4)
- Do not pressure into producing bad data. (4)

ALL OTHER RESPONSES

- Quality not measured by SSR only. (3)
- Be cautious of overhead affects on data. (3)
- Put audit requirements on contract. (3)
- Define prevention costs better. (3)
- When COQ should be applied by the government. (3)
- Normalize data and do not expose the contractor. (3)
- Use goal setting so contractor knows how he doing. (3)
- Appreciate product mix and quality system differences. (2)
- Use phased in approach, like on 1567.
- Top level in government sees need for defect reporting supported by COQ; lower level fragmented at system level, no emphasis on effectiveness.
- Use transition process to get better quality.
- Recognize that looking at percent reduction is wrong.
- Be positive.
- Engineering effort is often intangible.
- Hard to find engineering measure you can track statistically.
- Measure down to low enough level to be useful.
- A good measurement base is needed.
- Better definition of government upper and lower limits.
- Back off on getting vendor costs.
- Emphasize prevention.

- Prevention costs not worth the effort.
- Handbook 50 not contractual, but used to evaluate.
- Train government and industry on what is desired in Cost of Quality
- Get company officials to buy into Cost of Quality.
- Vendor Cost of Quality very important and has big savings potential.

RESULTS OF ON-SITE INTERVIEWS

CONTRACTOR VISITS

In addition to the 63 contractors interviewed over the telephone, on-site visits were made to two contractors, one Defense Contract Administration Services (DCAS) Regional Headquarters, and one recognized cost of quality expert in the world of academia.

Both of the contractors visited were under DCAS surveillance. They confirmed that during their recent cost of quality audits conducted by DCAS, the focus was on FAILURE costs only. (See comments in Chapter 2, pages 2-8 to 2-12). Although DCAS has expanded on what the people in the field should understand and look for in the cost of quality area in DLAM 8200.2, the contractors that were visited, as well as several of those contacted by telephone, made the point that the DCAS manual is not a contractual requirement, and they were not doing anything in terms of trying to comply with that manual. Both contractors also expressed concern over the fact in dealing with the government, they feel everyone wants something different. DCAS wants one thing, DCAA another, the Air Force yet another, and so on. In terms of what should be included in the handbook, the responses given by the contractors visited have been included in the lists of the industry "top 10" and "All Others", given above.

In our discussion with DCAS personnel, we found a great deal of consistency between what they saw as problems in dealing with cost of quality and what the contractors said (telephone and

those visited). For example, the emphasis must be on the use of cost of quality data, not on just having it available. Flexibility is needed to accommodate different product lines, different program phases, and different business management and financial accounting approaches. One point made was that it is difficult to ascertain at this stage what, if any, benefits are being realized through the contractors' corrective action board process by having/using cost of quality information. One opinion expressed was that doing a good cost of quality effort can be used effectively when tying in other government initiatives, such as Air Force GET SPEC, and emphasis on prime contractor of subcontractors.

GOVERNMENT DISCUSSIONS

In terms of what DCAS personnel recommended be included or covered in the handbook, these are the major items discussed.

- Standard base for expressing cost of quality would be beneficial.
- Documentation of contractor action taken as a result of reacting to cost of quality is lacking and is needed.
- Overhead rates vary too much, not true reflections of cost of quality burden. Should use FPRA rates, clearly defined. Need to standardize.
- Data must be traceable down to the nonconforming item.
- What corrective action should be included in cost of quality should be spelled out.
- Warranty costs must be clearly defined.
- Importance of "start up scrap", planned scrap

versus actual spoilage should be considered.

- Once elements are identified, data must be collected.
- Set no dollar threshold on what is good or bad for cost of quality.
- Clearly express the purpose of why government is looking at Cost of Quality and wants contractors to look at it.
- Allow contractor to use estimates, as long as he can justify the estimate.
- Must protect the data.
- Allow contractors to establish standards. Must be updated.

EXPERT OPINION

Our discussion with the recognized expert centered around that person's extensive experience in industry, academia, and as a key player for over 15 years with the American Society for Quality Control (ASQC) Cost of Quality committee activities. The highlights of our discussions focused on the fact that data has shown what big contributions are made by functional activities other than just the quality department to a company's total cost of quality. For example, there is typically a heavy emphasis on test activities, to verify or prove the quality of the product. Often, as much as 70% of the quality budget is spent in test. But, production operator inspection has been found to be a bigger cost than formal quality department inspections. Companies today are doing everything they can to reduce direct labor to aide

profitability. With proper use, cost of quality would pay much bigger dividends, because it attacks the entire organization. Direct labor is typically, although not always, a fairly small percentage of the total cost of an item. The preferred base for measuring cost of quality is "percent of value added". The most important aspect of having the cost of quality, other than using it, is the fact that you now have "defined the quality system", expressed in terms of the cost of that system.

APPENDIX C
PROPOSAL REVIEW CHECKLIST

PROPOSAL REVIEW CHECKLIST

.	Is proposed contractor effort required by SOW?	YES____ NO____
2.	Has the contractor interpreted the SOW tasking properly?	YES____ NO____
3.	Should the desired scope of the SOW tasking be clarified for the contractor?	YES____ NO____
4.	Is effort required to produce hardware?	YES____ NO____
5.	If not required for production of hardware, is effort required to support fielded system?	YES____ NO____
6.	Are resources applied reasonably for task?	YES____ NO____
7.	Are correct skill level personnel applied?	YES____ NO____
8.	Is timing of effort and applied resources consistent with build schedule?	YES____ NO____
9.	Is effort or applied resources redundant with any other WBS element?	YES____ NO____
10.	Is effort or applied resources redundant with any prior contract task element?	YES____ NO____
11.	Is effort being accomplished efficiently?	YES____ NO____
12.	Do the combined magnitude of hours and interrelationship between labor categories appear reasonable when graphed together?	YES____ NO____

APPENDIX D
SAMPLE AWARD FEE
EVALUATION CRITERIA

SAMPLE AWARD FEE EVALUATION CRITERIA

I. FEE DETERMINATION

A. Evaluation Criteria

The evaluation criteria and relative weightings are as follows:

1. Improvement Goals - Achievement of quality improvement goals stated in Program Task Plans (PTP) based in part on use of cost of quality data. (20%)

2. Schedules - Reasonableness of projection and degree of achievement of the following PTP milestones consistent with the Statement of Work priority system (10%).

   a. Capturing cost of quality

   b. Dissemination of cost of quality

   c. Evidence of use of cost of quality

   d. Results of cost of quality based improvement projects

3. Budget Projection - Ability to accurately project WBS 3rd level budgets (a comparison of WBS 3rd level budgets versus projected WBS 3rd level EAC's) (15%).

4. Cost Control - Ability to control the cost of the total quality effort (cumulative budget to date versus cumulative actuals to date) (15%).

5. Cost of Quality Management - Efficiency/effectiveness of accomplishing cost of quality objective in support of the program (15%).

6. Responsiveness - Quality/timeliness/completeness/appropriateness of the Contractor's responsiveness to Government direction in the cost of quality area (15%).

7. Program Reviews - Quality/timeliness/completeness/appropriateness of use of cost of quality information in reviews (including technical, management, and business aspects) (10%).

II. MANAGEMENT

Achievement of a Prevention Emphasis (Award Fee Available:)

OVERALL OBJECTIVE: Aggressive and innovative pursuit of improved Prevention Cost Effectiveness which provides increased mission capability, better long-term readiness, and more cost-effective support.

A. Management Awareness - Direct involvement of management that demonstrates their commitment to Prevention Cost Effectiveness improvements resulting from better application of preventative measures, which include:

- o Thorough Prevention planning that has maximum cost effectiveness as demonstrated by reduced failure costs.
- o Program management support demonstrated by instituting program-wide prevention policies that promote improvement of Quality, and lower total cost of Quality.

B. Engineering Analysis - Development of innovative methods to assess Prevention measures. Criteria for evaluation will include:

- o Approaches to predicting and evaluating potential problems to support prevention planning and implementation
- o Utilization of prevention techniques that enhance confidence in early achievement of requirements.

C. Management of Vendors - Positive measures taken to affect improvement of prevention of defective output through management of vendors. Specific evaluation criteria are:

- o Timely identification and resolution of problems that arise in the prevention management area of cost of quality.

D. Testing - Achievement, as rapidly as possible, of maturation of reliability in order to maximize FSD mission success rate and insure readiness at IOC.

Criteria for evaluation will include:

- o Early completion of scheduled reliability tests that result in early accomplishment of other tasks on the program schedule.

- o Incorporation of prevention fixes that enhance weapon system performance and supportability goals.

III. TECHNICAL AND OPERATIONS (Award Fee Available:)

OVERALL OBJECTIVE: Aggressive, comprehensive use of cost of quality as a management tool during design, development, manufacturing, quality assurance, subcontract management, and test efforts which drive superior operational effectiveness, system performance, and overall schedule accomplishment without compromising cost and supportability objectives.

A. Engineering Management - Evaluation will focus on design, development, and test tasks. Criteria will include:

- o Problem Resolution: Rapid identification, through use of cost of quality information, of problems and development of thorough corrective-action plans. Rapid implementation of solutions that optimize benefits to the overall weapon system.

- o Major Reviews: Thorough planning and professional execution of major reviews. Rapid response to action items with creative resolution of areas disagreement.

- o System Performance Validation: Early completion of successful Flight Worthiness and Qualification Testing. Rapid evaluation of flight test data and early validation of system and component performance.

B. Quality Assurance - Implementing Quality Improvement Programs (QIPs) which are based on cost of quality indicators at suppliers. Areas to be evaluated at suppliers will include:

- o Top level management and commitment to improve quality, through use of cost of quality.

- o Annual improvement goals which are measured and reported.

- o Training and awareness programs.

C. Manufacturing Management - The ability of manufacturing management organization to exceed expectations and contractual requirements. Emphasis will be placed on use of cost of quality data in the areas of:

- o Management visibility

- o Internal schedule status

- o Productivity and Quality Improvement Programs

- o Timely identification and resolution of production risks

D. Subcontract Management - The ability of subcontract management organization to exceed Air Force expectations and contractual requirements in managing subcontracts and materials requirements, particularly with the critical subcontractors. Emphasis will be placed on use of cost of quality data in the areas of:

- o Management visibility

- o Schedule status

- o Productivity and Quality Improvement Programs

- o Timely identification and resolution of production risks

E. Test Program - Timely, flexible, and substantial testing of the entire system, component functions, and performance. The evaluation will be based on use of cost of quality data as an integral part of:

- o Imaginative and innovative efforts to effectively plan and document the test program.

- o Perceptive approaches to accomplish test objectives.

- o Superior management application of resources to stay on or ahead of schedule.

IV. PROGRAM MANAGEMENT (Award Fee Available:)

OVERALL OBJECTIVE: Efficient, creative, and integrated management approaches which stimulate superior cost effectiveness, enhanced system performance, and fulfillment of requirements well ahead of schedule, through integration of cost of quality as a key management tool. Implementation should be through disciplined management approaches employed in a timely manner.

A. Interface Management - How thoroughly and expeditiously the Contractor resolves management issues highlighted by cost of quality data. Items of interest include:

- o Interface management communications.
- o Adherence and adequacy of interface management plans.
- o Functional implementation and reporting of interface efforts.

B. Configuration Management - Operation in an active management mode, using innovative and creative methods to identify potential trouble areas and resolve issues surfaced by cost of quality indicators before they become problems. Items of interest include:

- o Changes to established baselines.
- o Configuration of each end item.
- o Quality of data to enhance the streamlined management approach of the _____.

D. Schedule and Cost Control - Creative management action that greatly improves schedule cost performance through the use of cost of quality data while meeting/exceeding the program schedule milestones. Items of interest include:

- o Ingenious plans to avoid potential cost overruns through use of cost of quality as an integral part of program cost management.
- o Creative planning to meet/exceed major scheduled program milestones.